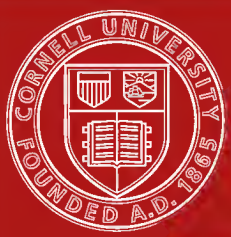

IMPERIAL MINERAL RESOURCES BUREAU.

THE MINERAL INDUSTRY OF THE BRITISH EMPIRE

AND

FOREIGN COUNTRIES.

WAR PERIOD.

MANGANESE.

(1913–1919.)

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PREFACE.

The following digest of statistical and technical information relative to the production, consumption and value of Manganese will form a part of the volume or volumes on the Mineral Resources of the British Empire and Foreign Countries constituting the Annual Mineral Conspectus of the Bureau.

In this, the first year of publication, an effort has been made to fill in, as far as possible, the hiatus due to the war in the publications relating to mining and metallurgical statistics. Labour, health and safety statistics have been omitted owing to the difficulty involved in procuring reliable information for the war period, but in future issues these statistics will be included in respect of each year. Resort will also be had to graphical representation of statistics of production, consumption, costs, and prices.

The weights are expressed in long tons, that is to say, the British statute ton of 2,240 lb., and values in pounds, shillings and pence at par rates of exchange.

R. A. S. REDMAYNE,
Chairman of the Governors.

2, Queen Anne's Gate Buildings,
London, S.W.1.

May, 1921.

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GENERAL.

Ore Minerals.

The manganese ore minerals of commercial importance include :—(1) *pyrolusite* (MnO_2), containing when pure 63·2 per cent. of manganese; (2) *braunite* ($3\ Mn_2O_3 + MnSiO_3$), containing 64·3 per cent. and having a silica content sometimes as high as 8 to 10 per cent.; (3) *manganite*, or "grey manganese ore" ($Mn_2O_3.H_2O$), containing 62·5 per cent. of manganese; (4) *hausmannite* (Mn_3O_4), containing 72 per cent.; (5) *psilomelane*, a complex hydrated oxide or manganate of doubtful composition, containing from 45 to 60 per cent. of manganese, with varying amounts of barium and potassium; (6) *wad*, or "bog manganese," an amorphous earthy mixture of hydrated manganese oxides with oxides of cobalt, copper, and iron, the manganese content varying from 5 to 50 per cent.; (7) *rhodochrosite*, or *dialogite*, the carbonate of manganese ($Mn\ CO_3$), containing 47·8 per cent. of manganese; (8) *rhodonite*, the silicate of manganese ($MnSiO_3$), containing 41·86 per cent. of manganese.

Of these, the most important are the oxides, including pyrolusite, psilomelane, and braunite.

Other important manganese minerals include :—(9) *manganiferous iron-ores*, highly variable mixtures of manganese oxides and iron oxides, in which the proportion of iron usually exceeds 40 per cent., while that of manganese may sometimes be as low as 5 per cent.; (10) the *manganiferous zinc-ore*, *franklinite*, $(Fe,Zn,Mn)\ O.\ (Fe,\ Mn)_2O_3$, containing 10 to 19 per cent. of manganese; (11) *manganiferous silver-ores*, mixtures of manganese and iron oxides (the latter generally in excess of the former) with varying small amounts of silver and lead minerals.

Manganiferous ores have commonly been divided into :—(1) *iron ores*, containing less than 5 per cent. of manganese (below which content the manganese is not paid for); (2) *manganiferous iron-ores*, containing 5 to 40 per cent. of manganese; and (3) *manganese ores*, containing not less than 40 per cent. of manganese.

Under this nomenclature, a manganiferous iron-ore might actually contain more manganese than iron, and, to avoid that difficulty, L. L. Fermor, in 1909,[1] proposed the following classification as being more rational :—

	Percentage of manganese.	Percentage of iron.
Manganese ores	40 to 63	0 to 10
Ferruginous manganese-ores ...	25 ,, 50	10 ,, 30
Manganiferous iron-ores ...	5 ,, 30	30 ,, 65
Iron ores	0 ,, 5	45 ,, 70

This table is applicable to all ores with over 50 per cent. of Mn + Fe, and the classification is roughly conformable with the

[1] The Manganese-Ore Deposits of India, by L. L. Fermor; Mem. Geol. Surv. India : Calcutta, 1909, *37*, 500.

product to be manufactured from each, the divisions corresponding roughly to higher grade ferro-manganese, low-grade ferro-manganese, spiegeleisen, and pig-iron respectively.

In the United States, the use of the following classification of manganese-bearing raw materials, adopted during the war, is being continued :—

	Per cent. of manganese.
Manganese ore, containing more than ...	35
Ferruginous manganese-ore, containing ...	10 to 35
Manganiferous iron-ore, containing	5 ,, 10

The lowering of the specification for ferro-grade ores from a minimum of 40 per cent. manganese to a minimum of 35 per cent. took place in the United States in May, 1918, when the standard content of ferro-manganese was lowered from 78—82 per cent. to 70 per cent. manganese. The object of relaxing ore specifications was to widen the market for the leaner and more siliceous domestic ores, at a time of stress, and it is considered probable that former specifications will be revived with the return of normal conditions. Investigations showed that both spiegeleisen and silico-manganese could be produced from lean domestic ores, this enabling the high-grade domestic ores to be conserved and reducing the need for high-grade foreign ores.*

Manganiferous zinc residuum is a product obtained by roasting franklinite, after mechanical and electromagnetic separation from the other zinc minerals (willemite and zincite) with which it is associated in the unique deposits occurring near Franklin Furnace, New Jersey, U.S.A., the zinc being volatilized and collected as zinc oxide. The residuum contains from 12 to 15 (commonly 14 to 15) per cent. of manganese, and about 40 per cent. of iron, and is smelted to spiegeleisen in blast-furnaces.

The term *manganiferous silver-ore* is applied in the United States to raw materials, whether oxides or carbonates, containing more than 5 per cent. of manganese, and sufficient silver to make them more valuable as a source of silver than for manganese. As found in the U.S.A., such materials commonly contain 5 to 45 per cent. of iron, several per cent. of silica and lead, and a little gold and copper. They are shipped to lead- or copper-smelters, where the silver, gold, lead and copper are recovered. The manganese aids in making a fusible and fluid slag.

Uses of Manganese Ores.

1. *Metallurgical.*—Probably about 95 per cent. of the world's production of manganese ores, manganiferous iron-ores (using the term broadly), and manganiferous zinc residuum is

* C. M. Weld and others ; Manganese Uses, Preparation, Mining Costs and the Production of Ferro-Alloys · Bull No 173, Bureau of Mines, Washington, D. C. 1920, 5–7

used directly or indirectly in the manufacture of iron and steel, the small percentage of true manganese ore not so consumed being used in the chemical, electric dry-battery, glass and paint industries. The greater part of the ore used in metallurgy is consumed in the making of the ferro-alloys required for steel-production (ferro-manganese, spiegeleisen, silico-manganese and silico-spiegel), while the remainder—consisting wholly of manganiferous iron-ore—is used for the direct production of manganiferous pig-iron. Self-hardening steels, made before the development of "high-speed tool steels," contained from 3½ to 4 per cent. of manganese. Nickel steels containing from 20 to 25 per cent. of nickel and 5 to 6 per cent. of manganese have been largely used for many years, for electrical resistance-wires.

The quantity of manganese consumed in the manufacture of "manganese bronze," "silver bronze," and other special alloys is relatively unimportant. The average manganese bronze of commerce may contain traces only of manganese, the amount never exceeding 1 per cent. The higher grades contain not more than 0·05 per cent. of manganese. The principal function of manganese in the ferro-manganese or (as perhaps more usual in modern practice) the cupro-manganese added to the copper-zinc alloy is to act as a deoxidizer. When ferro-manganese is employed, the small amount of iron thus introduced into the "bronze" is stated to increase appreciably the strength and toughness of the alloy, the most important use of which is in the manufacture of steamship propeller blades. It is beyond the scope of this publication to refer at length to the numerous special bronzes and brasses containing manganese that are of industrial importance.

2. *Chemical and General.*—

(*a*) *As Oxidizing Agents*: Manganese dioxide is extensively used in the manufacture of dry-cell electric batteries, and for decolorizing glass—to which a slight amount of iron in the form of ferrous silicate gives a green tint. (For decolorizing glass, from 2 to 15 lb. of manganese ore, of about the same high grade as that for dry-cell manufacture, is required per 1,000 lb. of sand, a larger addition resulting in an amethyst tinge, while, if as much as 30 lb. is added, a black glass is produced.*) Manganese dioxide and salts prepared therefrom are extensively used as driers of paints in linseed or other drying oils, the quantity added to the oil being usually less than 0·5 per cent. The dioxide is also employed in the manufacture of manganates and permanganates of sodium and potassium, used as disinfectants, for purifying various gases, and for other purposes. It has been extensively used in the manufacture of

* Eng. and Min. Journ., New York, 1919, *108*, 242.

chlorine, but this gas is now obtained in the United Kingdom, the United States, and other large chlorine-producing countries almost entirely by electrolysis of either chloride of sodium or chloride of potassium. The dioxide is still used in some laboratories for the production of oxygen on a small scale.

(*b*) As *Colouring Materials:* Manganese compounds are used to colour glass, pottery, tiles, and bricks, in calico-printing and dyeing, and for certain paints (brown, green, and violet).

(*c*) As *Flux:* Certain manganiferous ores from the weathered parts of silver-lead deposits are used as a flux in smelting lead and silver ores.

(*d*) *Miscellaneous Minor Uses:* Salts of manganese have been used experimentally as fertilizers in the production of rice and leguminous crops, but their value for this purpose has not yet been established; massive rhodonite is in limited demand as an ornamental stone in the United States; and there are certain medical and other minor uses for manganese compounds.

Value of Metallurgical Manganese Ores.

The value of metallurgical manganese ores depends on (1) the percentage contents of manganese and iron; (2) the percentages of objectionable impurities (phosphorus, silica, alumina, copper, cobalt, lead, zinc, barium, etc.); and (3) the physical condition in which the material is delivered at the blast-furnace.

A basis of 50 per cent. manganese has long been common in the European steel industry, with a penalty for each unit below that percentage and generally a premium for each unit above it. Ores of " ferro " grade, *i.e.*, for the production of the standard grade of ferro-manganese, are usually required to contain not less than 40 per cent. of manganese when dried at 212° F. Silica is generally penalized in Europe when in excess of 8 per cent. Phosphorus should not exceed 0·20 per cent., a penalty being imposed in the United Kingdom for each 0·01 or 0·02 per cent. in excess of 0·15 per cent. Alumina in excess of 10 per cent. is very objectionable, especially when silica is also high; while the other impurities mentioned above are objectionable in the smallest appreciable quantities. The ore, being shipped as ballast when intended for metallurgical purposes, should be sufficiently hard and tough to withstand excessive disintegration between mine and destination, and should arrive in coherent lumps, with a minimum of fines and dust, if it is to be used for blast-furnace production of manganese alloys.

During the earlier months of 1913, the price per unit* of manganese in first-grade manganese ore delivered *c.i.f.* at United

* 1 per cent.; equivalent to 22·4 lb. in a ton of 2,240 lb.

Kingdom ports was 10*d.* to 1*s.*, and for the remainder of the year 9½*d.* to 11½*d.*, until December, when the quotation was 9*d.* to 10½*d.* Between that month and the outbreak of the war, the price fell gradually to 8½*d.* to 9½*d.* per unit. During the war there was no open market for manganese ores in this country.

The prices paid according to analyses for metallurgical manganese ores imported into the United States are not disclosed, and can be estimated only approximately from the *c.i.f.* values of shipments from the various exporting countries as recorded by the United States Customs authorities. Price schedules for high-grade domestic ores have, however, been issued at intervals by the Carnegie Steel Company, these governing the United States market in normal times. The following table* summarizes schedules issued by the company in recent years :—

Prices Paid for Domestic Manganese Ores in the United States.

Year.	Prices per unit for Manganese percentages ranging from				Price per unit of Iron.	Silica standard.	Phosphorus standard.
	40 to 43.	43 to 46.	46 to 49.	49 and over.			
	cents.	cents.	cents.	cents.	cents.	per cent.	per cent.
1910	23	24–25	25	26	5	8	0·20
1914	—	24	25	26	—	8	0·20
1915	36	40	43	45	—	8	0·20
1916–17	46	50	53	55	—	8	0·20

These prices are based on long tons for material (samples dried at 212° F.) delivered at the furnace : silica penalty, 15 cents per ton for each unit over 8 per cent. ; phosphorus penalty, up to the year 1910, 1 cent. per unit of manganese for each 0·02 per cent. of phosphorus over 0·10 per cent.—thereafter, 2 cents per unit of manganese for each 0·02 per cent. of phosphorus over 0·20 per cent. Payment for the iron in manganese ores of "ferro" grade was discontinued in the United States several years ago.

During the war period the Carnegie Steel Company issued no schedules of domestic metallurgical manganese ore prices after May, 1917, but on 28th May, 1918, a new schedule, adopted by the Ferro-Alloys Committee of the American Iron and Steel Institute and approved by the War Industries Board, became effective, remaining so until 1st January, 1919. This schedule represented a slight advance in the price of most ores with less than 10 per cent. of silica, and covered manganese percentages ranging from 35 to 54 and over.

* Mainly Min. Res. of the United States (Annual), U.S. Geol. Surv., Washington, D.C.

Prices given in the Carnegie Steel and other American schedules apply to ferro-grade ores only. Those for "ferruginous manganese-ores," containing from 10 to 35 per cent. of manganese, have always been subject to individual contract.

C. M. Weld (*op. cit.*, 8) remarks that, when the alloy to be produced is silico-manganese or silico-spiegel, a much higher content of silica is acceptable than with ores to be used in making ferro-manganese or spiegeleisen, but the two former alloys can advantageously be made only in the electric furnace. Ores with 30 to 40 per cent. of manganese and 20 to 25 per cent. of silica can be used to advantage in making silico-manganese. The ratio of silica to manganese may be still higher if the usual slag-making constituents are relatively absent. It is also probable that at least a part of the phosphorus in the ore may be volatilized in the electric furnace, thus raising the permissible limit of that element. Roughly, the same holds good for silico-spiegel, with the substitution of iron for a part of the manganese.

Practically all the iron in manganese ores of ferro grade goes into the alloy produced, to that extent crowding out manganese. In general, the permissible ratio of iron to manganese in the ore would be about 1 to 10 for 80 per cent. ferro-manganese and 1 to 5 for 70 per cent. ferro-manganese. Ores for the manufacture of spiegeleisen may contain a much larger proportion of iron. No exact specifications for ores of this class have been customary in the United States. In general, the silica and phosphorus requirements have been about the same as for ferro-grade ores, the balance consisting of manganese and iron in varying ratio, together with gangue materials, such as alumina, lime and magnesia (Weld: *loc. cit.*).

Comparison of Prices of Ferro-Grade Manganese Ore and Ferro-Manganese in the United States.

(C. M. Weld: *op. cit.*, 12. Data largely from Metal Statistics, New York, 1918.)

Year.	(1) Price of 80 per cent. Ferro-manganese per ton. $	(2) Price per unit of Manganese in Ferro-manganese. $	(3) Price per unit of domestic Ore containing 46 per cent. of Manganese, delivered at furnace. $	(4) Ratio between unit price of Manganese in "Ferro" and that of Manganese in the Ore. (Col. 2 divided by Col. 3.)
1913 ...	57·87	0·72	0·25	2·88
1914 ...	55·80	0·70	0·25	2·80
1915 ...	92·21	1·15	0·40	2·88
1916 ...	164·12	2·05	0·50	4·10
1917 ...	309·17	3·86	0·75*	5·15
1918 ...	285·00	3·56	1·23*	2·93

* Estimated averages.

The last column in the above table indicates that, although the ratio between the unit price of manganese in ferro-manganese

and that of manganese in the ore was abnormally high during 1916 and 1917, the price adjustments of 1918 brought this ratio back nearly to the figures for 1913-1915. The ratio shown for 1918 was possibly less favourable to the furnaces than that for 1913-1915, owing to the great increase of conversion cost through high costs of labour, fuel, and supplies.

Value of Manganese Dioxide for Chemical Uses.

The value of manganese ore for use as an oxidizer in non-metallurgical industries depends essentially on its content of available oxygen, *i.e.*, the amount of oxygen obtainable from the ore by the action of acids. This is usually stated in terms of manganese dioxide (MnO_2). The following table by L. L. Fermor (*op. cit.*, 598) shows the proportions of MnO_2 and available oxygen and manganese dioxide present in pyrolusite and psilomelane:

	Pyrolusite.	Psilomelane.	
	MnO_2.	Ba_2MnO_5.	Mn_2MnO_5.
Available oxygen	18·39	7·81	13·06
MnO_2 equivalent of available oxygen	100·00	42·46	77·33
MnO_2 present	100·00	21·23	77.33

The available oxygen in psilomelane should range around 13 per cent., corresponding to about 77 per cent. MnO_2. In actual practice these figures are slightly less, owing to a little mechanically-included impurity. Manganite contains only 49·44 per cent. MnO_2; braunite, only 43·11 per cent.; hausmannite, only 37·99 per cent.; rhodonite and rhodochrosite, *nil*. As the basis for chemical purposes may be 60, 70, 80, or even 90 per cent. MnO_2, pyrolusite is obviously the best ore, psilomelane may often be good enough, while the other ordinary manganese ore-minerals are of little or no use to the chemist.

Before the war, high-grade Russian (Caucasian) pyrolusite was almost exclusively used in this country and in the United States for the manufacture of dry-cell electric batteries, British specifications calling for 86 per cent. MnO_2 and not more than 1 per cent. of iron. In the flint glass and dry-cell industries of the United States, specifications call normally for 80 to 90 per cent. (commonly 80 to 85 per cent.) MnO_2, but in 1918 ores with only 70 per cent. were accepted. The higher grades are still required for the manufacture of flash-light batteries.

It has been customary in the United States to require that the iron content in ore for these two industries should not exceed 1 per cent., but that limit is now regarded as being probably arbitrary as relating to dry cells, and it has been recently stated that 2 or 3 per cent. or even more of iron as oxide does not greatly

affect the efficiency of such cells. During the war, manufacturers of dry cells in the United States accepted material running as high as 3 to 4 per cent. iron (Weld : *op. cit.*, 19).

Copper, nickel, cobalt, and arsenic, which are electro-negative to zinc, are the most harmful impurities in ordinary dry-cell batteries, and none of these should exceed a few tenths of 1 per cent. Lime, in the form of carbonate, should not exceed about 2 per cent. in manganese ores intended for use as oxidizers, and may be required to be entirely absent. Phosphorus is harmless in ores employed for the production of chlorine. For colouring pottery, tiles, and bricks, argillaceous and siliceous ores containing less than 40 per cent. metallic manganese have been used. For glass-making, siliceous pyrolusite is acceptable, but carbonaceous pyrolusite is objectionable.

As to physical condition : manganese ore to be treated in stills should be sufficiently porous to allow of the percolation of acid, and so compact as not to crumble; ore to be used for dry cells or for flint glass manufacture, when the melting is done in pots, if not received in a finely divided condition, requires crushing and pulverizing, a common specification for the former use requiring that the run of material shall pass through a 10-mesh or a 20-mesh screen, while some manufacturers require the removal of the dust. When the melting is to be done in tanks, lump or granulated manganese ore is commonly used in glass-making, the objection to its use in such forms, namely, the time required to melt it into the batch, applying particularly to pot-melting.

The prices of " battery," " chemical," or " dioxide " ores rose very considerably during the war in this and other countries, such ores, formerly worth $20 to $35 per ton in the United States, selling there (best grades) for $80 to $100 per ton delivered. It was estimated in 1918 that the demand for manganese ore for dry cells and flint glass in the United States was then at the rate of about 35,000 tons per annum.

Ferro-Manganese and Ferro-Manganese-Silicon Alloys.

The iron-manganese alloys principally used in steel manufacture are *ferro-manganese* and *spiegeleisen*. These contain varying amounts of carbon and silicon, and minor impurities. In comparatively recent years alloys of iron with manganese and silicon, intermediate between ferro-manganese and ferro-silicon, have been employed to an increasing extent in the manufacture of steel. These compounds, which contain a considerable amount of silicon, are known as *silico-manganese* or *silico-spiegel* (*silicon ferro-manganese*), respectively, according to the manganese content.

The name ferro-manganese has been rather loosely applied to alloys of iron and manganese containing not less than 25 per cent. of manganese; but, as made on a large scale in the United

Kingdom and the United States, standard ferro-manganese is normally guaranteed to average 80 per cent. of manganese or over, the commercial alloy ranging ordinarily in this country from about 70 to 80 or (rarely) 88 per cent. British ferro-manganese contains less phosphorus than that made on the Continent.

The lower alloy, spiegeleisen, as made in Europe, may contain from 10 to 35 per cent. of manganese, but the percentage ranges commonly from 18 to 22. British and American standard spiegeleisen contains ordinarily about 20 per cent. of manganese.

Analyses of many samples of typical ferro-manganese and spiegeleisen show that the carbon content decreases slightly as the percentage of manganese increases. Harbord and Hall* remark that the phosphorus content should not exceed 0·10 per cent., and if possible not 0·06 per cent., but that it is often very difficult in these days to obtain ferro-manganese and spiegeleisen with so low a content of phosphorus, this being one of the difficulties with which steel makers have to contend in the manufacture of steel very low in phosphorus.

Ferro-manganese can be made only from high-grade manganese ores, but spiegeleisen can be manufactured from manganiferous iron-ores, manganiferous zinc residuum and other raw materials with low manganese content. Ferro-manganese can be used for either Bessemer or open-hearth steel-making processes, but has normally been used only in the latter. Before the war, spiegeleisen was used only in Bessemer practice. For making very low-carbon steel by any of these processes, ferro-manganese is necessary. The use of spiegeleisen in the making of open-hearth steel in the United States during the war was rendered necessary by the shortage of ferro-manganese supplies from Europe (chiefly from the United Kingdom).

Price of British Ferro-Manganese.

The average price of ferro-manganese (80 per cent. Mn) in the United Kingdom for 1913 was about £9 per ton. In 1915 the price for home consumption was fixed by the Ministry of Munitions at £20 per ton. In February, 1916, it was raised to £25 on account of increased freights on imported manganese ore, and in January, 1918, it was further raised to £26 10*s.* per ton. In March, 1919, the price fell to £25 per ton, and in November, 1919, to £23. For export to allied countries the prices were kept open during the war period. At the end of November, 1920, the official quotations were £37 per ton for home trade and £45 per ton for shipment, unofficial export quotations being about £52 to £53 per ton.

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* F. W. Harbord and J. W. Hall; The Metallurgy of Steel: London, 1918, 1, 55.

Analyses of British Ferro-manganese and other Alloys.

The following analyses show the composition of ferro-manganese and spiegeleisen of about the standard grades, and of manganese-iron-silicon alloys, as made in the United Kingdom :—

		Analysis : per cent.					
		Manganese.	Iron.	Carbon.	Silicon.	Sulphur.	Phosphorus.
Ferro-manganese :							
	(*a*)	82·00	9·90	6·58	1·00	Trace	0·12
	(*b*)	80·62	(*x*)	7·00	0·30	Nil	0·159
	(*c*)	80·00	11·80	7·20	0·80	0·004	0·180
Spiegeleisen :							
	(*d*)	20·40	73·20	5·00	1·10	Trace	0·06
	(*e*)	20·11	(*x*)	4·99	0·42	Nil	0·074
	(*f*)	20·00	73·90	5·20	0·75	0·008	0·05
Silico-spiegel :							
As made in Blast Furnace.	(*g*)	17·50 to 20·87	(*x*)	1·05 to 1·89	9·45 to 14·23	Nil	0·065 to 0·098
As made in Electric Furnace (chief grades).	(*h*)	50 to 55	(*x*)	1·0	20 to 25	0·03	0·06
	(*i*)	68 to 75	(*x*)	0·8	20 to 25	0·02	0·052
	(*j*)	50 to 55	(*x*)	0·65	30 to 35	0·02	0·04

(*x*) The difference between the percentages given and 100 is mainly iron.
(*a*) (*d*) F. W. Harbord and J. W. Hall : *op. cit.*, 55.
(*b*) (*e*) (*g*) Darwen and Mostyn Iron Co., Ltd.
(*c*) (*f*) Linthorpe-Dinsdale Smelting Co., Ltd.
(*h*) (*i*) (*j*) Ryland's Directory, London, 1920.
Samples (*a*) and (*d*) contain 0·10 per cent. of arsenic. The percentage of this element in the other samples is not stated.

In the United States, standard ferro-manganese (80 per cent. Mn, approx.) normally contains 7 per cent. of carbon and standard spiegeleisen (20 per cent. Mn, approx.) 5 per cent. of carbon.

In order to render practicable the use of the lower-grade domestic manganese ores in the United States during the war, the composition of ferro-manganese (formerly 78 to 82 per cent. manganese) and spiegeleisen (formerly 18 to 22 per cent. manganese) was considerably modified in that country, while silico-manganese and silico-spiegel came into somewhat greater prominence.

Approximate Range of Composition of Manganese Alloys as now commonly made in the United States.

(C. M. Weld, *op. cit.*—Data largely from E. Newton, Manganiferous iron-ores of the Cuyuna District, Minnesota : Univ. of Minn. Bull. No. 5, 1918.)

Alloy.	Manganese.	Iron.	Silicon.	Carbon.
	Per cent.	Per cent.	Per cent.	Per cent.
Ferro-manganese	50 to 80	40 to 8	0·5 to 1·5	5 to 7
Spiegeleisen	10 to 35	85 to 60	About 1·0	4 to 5
Silico-manganese ...	55 to 70	20 to 5	About 15·0	0·35
Silico-spiegel	20 to 50	67 to 43	4 to 10	1·5 to 3·5

The phosphorus must be so low that the alloy additions will not cause the phosphorus in the steel to exceed the specified limit, which is usually about 0·05 per cent. in the United States.

The quantity of manganese ore required to produce an iron-manganese alloy depends on the grade of alloy desired, the quantity of gangue impurities present in the ore, and the losses of manganese in smelting (which in good furnace practice may total 25 per cent.). Roughly, from $2\frac{1}{4}$ to $2\frac{1}{2}$ tons of high grade manganese ore are required to produce 1 ton of ferro-manganese (80 per cent. Mn).

The principal functions of manganese in steel manufacture are: (1) the promotion of chemical reactions—deoxidation and desulphurization, and (2) the imparting of certain chemical and physical properties to the purified metal—recarburization, and static properties due to the amount of manganese remaining in the finished steel. Unless deoxidizers are added, steel made by an oxidation process will contain gas-holes, the formation of which is to a greater or less degree prevented by the use of manganese alloy. An important effect of such addition is to impart fluidity to the slag, rendering it more easy to run off.

The proportion of manganese alloy added to the molten steel varies with the oxidation of the bath, the composition of the pig metal used, manganese losses in slagging and volatilization, and the amount of manganese required in the finished product. The average consumption of 80 per cent. ferro-manganese per ton of steel produced before the war was probably from about 18 to 20 lb. (roughly, 0·8 to 1 per cent.), the quantity of alloy required being sometimes as much as 25 lb. per ton. The trend of consumption of manganese in the form of alloys during recent years in the United States may be gauged from the following figures* :—For 1913-14, the combined production and imports of metallic manganese was 15·6 lb. per ton of steel produced, or nearly 0·7 per cent.; for 1915-16, 14·0 lb. per ton, or 0·625 per cent.; and for 1917-18, 14·3 lb. per ton, or 0·638 per cent. From this it would appear that the consumption of manganese in making steel in the United States during the war was nearly 10 per cent. less than in the years immediately preceding it. In the finished state, steel contains ordinarily from 0·3 to 1 per cent. of manganese.

The highest-grade ferro-manganese is used in the production of "manganese-steel," an alloy discovered by Sir Robert Hadfield in 1883. As now manufactured in this and other countries, manganese-steel may contain 11 to 14 per cent. of manganese (usually 12·5 to 13 per cent.); the carbon content is generally kept near 1 per cent., although it is sometimes 1·3 per cent. or slightly higher; the silicon content lies between 0·3 and 0·8 per cent., and that of phosphorus between 0·05 and 0·08 per

* Manganese and Manganiferous Ores in 1918, by D. F. Hewett: U.S. Geol. Surv., Min. Res. U.S.

cent. The sulphur content is so low as to be negligible. Low-manganese steels with 7 to 8 per cent. of manganese (known as "loman steel") are finding some use, these having a higher and better defined elastic limit than the regular commercial grades, and yet with considerable though much less ductility. They are also cheaper to make.* Commercial manganese-steel is a self-hardening steel, possessing extreme hardness, great tensile strength, and high ductility; its elastic limit is very low and not well defined; it has a high coefficient of expansion; for a metal, it is a poor conductor of electricity; it is non-magnetic; it is almost free from blow-holes. Cast and hot-worked (rolled or forged) manganese-steels are largely used where strength and high resistance to abrasive wear are of special importance (as for the wearing parts of rock-breakers, crushing rolls, ball-mills and dredge-buckets, and for railway switches, crossings and rails used on curves, burglar-proof safes, etc.), although the practical impossibility of machining the parts has prevented its application to certain uses. The non-magnetic property and hardness of manganese-steel have brought it into important use for the cover plates and coil shields of electro-magnets for lifting heavy iron and steel articles.

Until comparatively recent years, both ferro-manganese and spiegeleisen were manufactured exclusively in the blast-furnace, a method that is wasteful of both manganese and fuel. The electric-furnace method of producing ferro-manganese was first used in 1899; but, owing to the losses of metal by volatilization due to excessively high temperatures, the development of production by that method was retarded, and it is only within the last few years that control of electric-furnace temperatures has been perfected. Ferro-manganese is now being produced commercially, on an appreciably increasing scale, in the electric furnace; and, in manganese-mining localities where hydro-electric power is very cheaply available and conditions generally are favourable, production by this method, which is less wasteful of manganese and gives a high-grade alloy, must become increasingly important. Against the low capital outlay involved and the low cost of labour required, however, there must be set off the high electrode consumption, which renders the cost of producing manganese alloys in the electric furnace higher than that of blast-furnace production. Silico-manganese and silico-spiegel can advantageously be made only in the electric furnace. The future of the electric-furnace method would appear to depend very largely on the continuance of a high price for the product.

WORLD'S PRODUCTION OF MANGANESE ORE.

Deposits of manganese ore are widely distributed throughout the world, but the occurrences of considerable commercial importance at the present time are limited to a few countries.

* Manufacture and Uses of Alloy Steels, by H. D. Hibbard, New York, 1919.

these including Russia (Caucasus), British India (southern and central), Brazil (States of Minas Geraes and Bahia), and West Africa (Gold Coast). The less important occurrences include those of Italy, Spain, the United States, Cuba and Japan. Deposits of ferruginous manganese-ore and manganiferous iron-ore are also widely distributed, occurring in the United States, Germany, Greece, Italy, and Egypt (Sinai Peninsula), while in the United States deposits of manganiferous zinc-ore and manganiferous silver-ores are extensively mined. Accounts of these and minor occurrences follow, under the respective countries.

For a long series of years before the war, the principal producer of manganese ore, properly so-called, was Russia, where production commenced in 1879. Production in British India started on a very small scale in 1892, in the Vizagapatam district, Madras Presidency; but it was not until after the discovery of the rich deposits in the Central Provinces, in 1899, that the Indian manganese ore industry became important relatively to that of Russia. Brazil followed in order of importance, manganese ore having been discovered in the State of Minas Geraes in 1888, although the first shipments were not made until 1894. The highest production reached by Russia in any year was 1,234,900 long tons in 1913; the record output for British India is slightly over 900,000 tons, in 1907; while the Brazilian industry reached its zenith during the war with a production of 524,291 tons (exports) in 1917. The manganese ore production of British India for 1908-11 exceeded that of Russia, this being to some extent attributable to political disturbances in the Caucasus; but in 1912 Russia resumed the leading position and retained it until the outbreak of the war, when her most important market, Germany, was abruptly cut off, and the subsequent closing of the Dardanelles stopped oversea shipments. The statistics of production given later show how the British-Indian manganese-ore industry also suffered during the war period, and how the Brazilian industry, the development of which had long been retarded by the distance of the principal mines from the nearest shipping port, and inadequate railway facilities, expanded rapidly as a result of the stoppage of Russian and the curtailment of British Indian exports to the United States.

Statistics have been tabulated by L. L. Fermor,* comparing the costs of production (including mining administration and royalty), road and railway transport, ocean freight, and destination charges, of Indian, Russian, and Brazilian manganese ores delivered *c.i.f.* at London. These show that, with low rates of exchange, the Brazilian ores could compete in that market in pre-war years on equal terms with those of India and Russia, while at a considerable disadvantage with high rates of

* Mem. Geol. Surv. India, 1909, *37*, 489.

exchange; also that the manganese ores of Vizagapatam, British India, cost less to deliver at London than those of the Central Provinces and Russia, and that the two latter cost about the same.

Assuming that the figures tabulated show the average cost fairly and that all the ores were first-grade, containing 50 per cent. of manganese, except the Vizagapatam ore which is assumed to have averaged 46 per cent. and to have fetched second-grade prices, then the prices per unit at which the ore could be sold at no profit or loss at the time when the comparison was made are as follows:—

	Pence per unit.
British India:—	
Central Provinces viâ Bombay	8·7
Vizagapatam	8·2
Russia:—	
Caucasus	8·5* to 9·4†
Brazil:—	
Minas Geraes	7·36‡ to 11·4‡

During the war Brazilian and other available ores were imported into the United States without the regard for cost that would have influenced buyers in normal times; but, with improved railway transportation from the State of Minas Geraes to Rio de Janeiro and better facilities for loading at that port, the Brazilian manganese ore industry, while continuing to find its best market in the United States, may perhaps become a more formidable competitor with India and Russia in European markets, although, when normal conditions are restored, Germany will certainly again obtain practically all her manganese ore supplies from Russia.

Tchiaturi (Caucasian) ore has a high phosphorus content, and is therefore more suited to the metallurgical requirements of the Continent, where the basic process of steel manufacture is so extensively employed, than to those of the United Kingdom, where manganese ore is chiefly consumed in the production of ferro-manganese. There has been a large demand in this and other countries for high-grade Caucasian manganese ore for the chemical, dry-cell, and flint-glass industries, a concentrate of exceptional purity, containing from 81 to 92 per cent. of manganese dioxide and less than 1 per cent. of iron, being obtained by washing the fine, earthy material. The cutting-off of such supplies during the war was especially felt by manufacturers of dry cells.

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* Demaret; *Annales des mines de Belgique*: Brussels, 1905, *10*, 886.

† Trans. Amer. Inst. Min. Eng., New York, 1898, *28*, 207.

‡ Demaret, *loc. cit.* 843, with exchanges at one milreis=7*d.* and 14*d.* respectively.

In 1913, Russia produced about 54·4 per cent. of the world's total output of manganese ore, British India about 35·9 per cent., and Brazil about 5·3 per cent., an aggregate of 95·6 per cent. The world's output in that year amounted to about 2,272,250 long tons.

The production of manganese ore by the principal producing countries in recent years is summarized, so far as trustworthy statistics are available, in the following table :—

Production of Manganese Ore by Principal Producing Countries.

Country.	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	5,393	3,437	4,640	5,140	9,942	17,456	12,078
Gold Coast*	—	—	—	4,258	31,136	30,292	35,189
Union of South Africa...	—	—	—	—	110	486	138
Canada	—	25	179	854	141	393	†
British India	815,047	682,898	450,416	645,204	590,813	517,953	534,995
Australia	27	26	1,260	3,196	4,006	8,891	4,969
Austria	16,280	13,586	11,738	†	†	177	†
Belgium	—	—	492	3,808	1,988	2,569	†
Bosnia-Herzegovina ...	4,624	4,054	10,254	22,310	48,066	†	†
France	7,608	6,290	10,158	10,633	11,403	9,712	4,738
Germany‡	748	†	†	939	598	1,017	544
Greece	—	—	401	3,542	—	5,045	†
Hungary	18,705	11,230	11,521	†	88,818	†	†
Italy	1,596	1,622	12,375	17,855	24,138	31,383	30,345
Russia and Georgia ...	1,234,900	891,400	528,900	247,000§	201,380§	150,000§	†
Spain	21,247	12,944	14,098	13,950	56,550	76,465	65,614
Sweden‖	3,937	3,584	7,485	8,751	19,554	16,304	12,081
Tunis	—	—	1,437	1,994	5,707	1,378	1,292
Costa Rica¶	—	—	—	1,244	7,163	9,680	9,988
Cuba	—	—	9,000	33,120	44,496	81,966	17,711
Mexico	—	—	—	—	72	2,832	2,258
Panama¶...	—	—	—	10,498	5,202	5,607	2
Porto Rico	—	—	—	737	1,189	1,350	†
United States	4,048	2,635	9,613	31,474	129,405	305,869	55,322
Argentina¶	—	—	—	—	6,600	849	2,305
Brazil*	120,335	180,679	284,032	495,044	524,291	387,066	319,777
Chile¶	—	—	—	—	202	2,998	441
Ecuador¶	—	—	—	—	—	107	20
Peru	—	—	—	—	—	20	†
China¶	—	—	—	—	20	2,997	1
Japan	17,755	16,803	25,470	48,547	50,579	56,109	†
Philippine Islands ...	—	—	—	2,952	—	640	†

* Shipments. † Statistics not yet available.
‡ Prussia only (complete statistics not available). § Georgia only.
‖ Not including "powdered pyrolusite," averaging about 100 tons annually.
¶ Exports actually received by the United States in those years.

Reserves of Manganese Ore.

The proved and probable reserves of manganese ore in the principal producing countries cannot be closely estimated, owing to the modes of occurrence of the deposits, which are

often masses of very irregular form, or ore-bodies of varying size (concretionary nodules and pockets, etc.) scattered through soft argillaceous rocks, or deposits of which only certain portions can be economically exploited for a variety of reasons (character of the enclosing rock, quantity of water to be pumped, etc.). In certain cases, as in British India, no attempt appears to have been made to prove by means of shafts or bore-holes the depths to which the deposits of manganese ore extend.

Discussing this subject in 1909, L. L. Fermor (*op. cit.*, 546-548) remarks that many deposits of manganese ore do not extend to greater depths than 50 feet. The mining and quarrying of manganese ore-deposits in different parts of the world has shown that the oxide ores have been formed, in the majority of cases, at or close to the surface, and do not extend to any considerable depth, say beyond 50 to 500 feet. If, however, any portions of the ores of the Central Provinces of India can be considered as metamorphosed sediments, such portions may be found to continue to as great a depth as the associated rocks of the gondite series, and this may in some cases be considerably more than 300 to 500 feet. The same remark applies to any other deposits, such as those of Sweden, that have been formed by the metamorphism of original manganese-oxide sediments. The franklinite deposits of New Jersey, U.S.A., in which the manganese-zinc-iron mineral is regarded by some as having been formed by the metamorphism of original sediments containing both manganese and zinc, and which has been proved by boring to continue to depths of more than 1,000 feet, may be cited as an example of a manganese-oxide mineral proved to continue to a great depth.

British India.—The following table shows the depths to which the Indian manganese-ore deposits had been proved at the date of Fermor's Memoir, and to which he considered that they might be expected to continue :—

Depths to which Indian Manganese Ore Deposits Extend.

Area.	Depth to which proved.	Depth to which deposits may in some cases be expected to continue.	Depth to which deposits may possibly continue in some cases.
	(1)	(2)	(3)
	Feet.	Feet.	Feet.
Central Provinces ...	80	150 to 200	300 to 500 (or more).
Vizagapatam ...	100	150 to 200	300 to 400
Sandur	50	80	100
Mysore	30	60	80

The figures in column (1) refer to the larger deposits only. In some cases in each area deposits have not continued even to

these depths. The figures in column (2) also apply to the larger deposits, such as Kándri, Kodur, Durgámma Kolla, and Kumsi, typical of each of the four areas mentioned. The figures in column (3) are the probable outside limits to which the most extensive deposits in each area may possibly persist. In the absence of any bore-holes or shafts proving the deposits to continue to any greater depths than those given in column (1), the other figures were based on theoretical guesses.

Fermor gives the following rough estimates of merchantable manganese ore in certain of the Indian deposits at the date of his Memoir :—

Central India.—

Jhábua State :—Kájlidongri deposit, 837,000 long tons (lying within 50 feet of the surface).

Madras Presidency.—

Sandur State :—Sandur Hills, 10,000,000 long tons (to depth of 80 feet).

Mysore State.—

Shimoga District :—Kumsi deposit, 300,000 long tons (to depth of 50 feet).

These deposits, of course, represent only a small percentage of the probable total reserves in the Indian deposits of manganese ore.

The northern portion of the *Kájlidongri* deposit averages from 46 to 52 per cent. of manganese, and the southern portion from 46 to 48. (For analyses see p. 52.)

It is suggested by Fermor that the manganese ore-deposits of *Sandur State* may possibly contain in all about 100,000,000 tons of ore, averaging about (but probably under) 50 per cent. of manganese. A considerable proportion of the 10 million tons which he regarded as already " probable " is described as being fairly ferruginous, and saleable as ferruginous manganese ore rather than as manganese ore proper. A typical analysis shows 45 per cent. of manganese, 12 per cent. of iron, about 1 per cent. of silica, and 0·01 per cent. of phosphorus.

As to the *Kumsi* deposit (Shimoga District), the estimate of 300,000 tons of ore to a depth of 50 feet is given as the probable maximum, with a bare possibility of 500,000 tons. The ores of the Shimoga District are usually of second or third grade, averaging about 47 per cent. manganese.

Russia and Georgia.—

Tchiaturi Deposits :—The quantity of manganese ore available for actual exploitation in these deposits has been variously estimated, the amounts ranging downwards from 200 million to 22 million tons. An estimate of about 110,000,000 tons appears to have been generally

adopted.* This ore, without cleaning or sorting, averages from 40 to 45 per cent. manganese.

Nikopol Deposits :—The total tonnage of ore available in these beds has been estimated at from 7,400,000 tons† to 11,250,000 tons.‡ H. K. Scott and others are of the opinion that the quantity of ore available is much greater than this. The better class of this ore contains about 57 per cent. of manganese.

Deposits in the province of Podolia, south-west Russia, also contain very large (unestimated) tonnages of manganese ore, and there are other more or less important sources of supply in that country.

Brazil.—

Minas Geraes :—The combined ore reserves of the two principal mines in this State (the Morro da Mina and the Wigg) were estimated in 1905 at more than 7,000,000 tons.§ In 1915 the reserves of the Morro da Mina mine alone were estimated (by the management) at 10,000,000 tons. The ore of this mine, as shipped, averaged 50·47 per cent. manganese before the war, but the grade fell appreciably before the Armistice, owing to the urgent demands of the United States.

Bahia :—Deposits of manganese ore that have been worked about 16 miles west of Nazareth, a town on the Jaguaripe river, 30 miles south-west of the port of Bahia, are estimated to contain more than 700,000 tons of ore.‖ The ore of the Pedras Pretas mine, the principal producer in this State, averages from 43 to 49 per cent. manganese.

Matto Grosso :—It has recently been estimated that there are about 120,000,000 tons of manganese ore in this State, with an average content of 45·6 per cent. manganese. The principal deposits are in the Morro de Urucum and the Morro Grande, west of the Paraguay River.

Maranhão :—It is estimated that one hill, in the Turyassú district, about 190 miles east of the port of Pará, in this

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* Beyschlag, Vogt and Krusch ; The Deposits of the Useful Minerals and Rocks : London, 1916, *2*, 1105 (Trans. by S. J. Truscott). E. C. Harder ; Manganese Ores of Russia, India, Brazil and Chile ; Trans. Amer. Inst.M.E., 1916, *66*, 38. (The estimate of 22,000,000 tons was given by H. K. Scott in a discussion of this paper.)

† E. C. Harder *loc. cit.*, 40.

‡ N. T. Belaiew and S. I. Atchkassoff : The Russian Economist : Journal of the Russian Economic Association in London, 1921, *1*, No. 2, 295–300.

§ U.S. Geol. Surv., Min. Res. U.S. 1905, 99.

‖ Miller and Singewald ; Mineral Deposits of South America : New York, 1919, 188.

State, contains about 300,000 tons of ore, averaging more than 48 per cent. of manganese, within 50 feet of the surface.

The foregoing estimates relate to the three principal producing countries. The reserves of manganese ore in other regions are mentioned, where estimates are available, under the respective countries as dealt with herein. Of these minor countries, the most important in the British Empire, as regards manganese ore production, is the Gold Coast.

Gold Coast (West Africa) :—It is estimated by the owners of the Dagwin Extension Concession that the detrital ore alone, lying on the surface and down to a shallow depth on that area, amounts to nearly 3 million tons. Ore at the outcrop of a deposit at the northern end of this property is stated to average 50 per cent. manganese over a proved length of about 2,200 feet. Estimates of the reserves on other sections of the property owned by the company exploiting the manganese ore deposits of the Wassaw district are not available.

Of the other producing countries, the United States, which is the largest consumer of manganese ore, may be mentioned :—

United States :—At the end of 1918, the amount of manganese ore containing 35 per cent. or more of manganese in sight in the deposits of the United States was estimated by the United States Geological Survey at 699,750 tons, with 1,130,000 tons more in prospect.

In addition, more than 17,000,000 tons of low-grade ore, containing from 5 to 35 per cent. of manganese, are estimated to be in sight in the known deposits.

BRITISH EMPIRE.

Of the few countries in the British Empire producing considerable amounts of true manganese ore, India stands conspicuously alone as a serious competitor with the two principal foreign producers, Russia and Brazil. Promising deposits are, however, being exploited in West Africa (Gold Coast), and recent discoveries in Canada and other parts of the Empire may prove to be of commercial importance, although in some cases these may furnish a portion only of the domestic requirements. Commercially valuable manganiferous deposits occur extensively in Egypt (West-Central Sinai), the ore cousisting of varying mixtures of oxides of iron and manganese. Of these deposits, the most important are those in the Um Bogma Hills, where, however, the average manganese content of the total reserves is only about 32 per cent., while the iron content is only about 25 per cent.

United Kingdom.

Manganese ore occurs in North Wales, the West of England, Derbyshire, Warwickshire, and Cumberland, also in Scotland and Ireland. The production of such ore in the United Kingdom has never been large, and, for many years, practically all the output has been obtained in North Wales, chiefly from mines in the Lleyn Peninsula, Carnarvonshire, and in smaller quantity from Merionethshire. The output of North Wales from 1892 to 1912 amounted to 91,133 tons, of which 81,429 tons were raised in Carnarvonshire and 9,704 tons in Merionethshire. The Welsh production since 1912 is shown in a table, from which it will be seen that there was a marked increase in the Merionethshire output during the period under review. It is unlikely that any considerable quantity of manganese ore could be profitably obtained from the other areas mentioned. A geological account of the various occurrences in the United Kingdom is given in Memoirs of the Geological Survey of England and Wales.*

Carnarvonshire.—Three mines, all situated in the Lleyn Peninsula, have furnished the manganese ore output of this county, namely, the Nant, the Benallt, and the Rhiw. From 1894 to the end of 1912 the combined production of the two former amounted to 68,084 tons, while from the Rhiw mine 13,345 tons were raised. Since 1908, practically the whole of the Welsh output has come from Nant and Benallt, the output since 1914 being almost entirely from the former, although from 1916 to 1919 about 40 per cent. of the production was obtained in Merionethshire.

At Nant, the ore occurs as a much-faulted bed, from 10 to 20 feet in thickness, interstratified with shales and flags of Ordovician age, and is worked by an incline from which several levels have been driven. The unaltered ore contains manganese in the form of carbonate (dialogite) with a small proportion of silicate (rhodonite), but it has been changed by weathering at the outcrop into a hydrated black oxide. The average content of manganese is only about 30 per cent. (some samples yielding 36 per cent.), that of iron only about 10 per cent., while the silica and phosphorus percentages are excessively high, having been stated† to average 18 per cent. and 0·3 to 0·5 per cent. respectively. The ore is shipped, in as large lumps as possible, to smelters in Liverpool.

At Benallt, several beds of manganese ore occur in the shales, which have been folded into an anticline, the limb that has been principally worked dipping at about 40° Both this mine and

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* Special Reports on the Mineral Resources of Great Britain, Vol. I.—Tungsten and Manganese Ores, London, 1915.

† The Mining Journal, London, 1907, *81*, 828.

its neighbour, the Rhiw, have been idle and full of water since 1913. The workings include adits, two shafts 110 feet in depth, and open workings from which apparently some ore could still be obtained. The average manganese content of the ore in these two mines is said to be 32 to 33 per cent., some samples reaching 38 per cent.

Merionethshire.—Manganese ore occurs in the Llanbedr district in the form of a bed of mixed carbonate and silicate interstratified with the Harlech grits. The bed of ore, which is traceable for many miles along the sides of river-valleys, varies in thickness from 10 to 20 inches, and is coated near the surface, and on the joints and cracks that traverse it, with impure black oxide of manganese, a decomposition product containing from 20 to 22 per cent. of manganese. The ore is richest in the weathered crust, which consists of earthy pyrolusite. Formerly this was dug, the carbonate and the silicate being rejected as useless. The value of this unaltered ore in glass-making was subsequently discovered, and the workings, which were abandoned about the middle of last century, have been to some extent re-opened. The ore won, broken into lumps about 2 inches across, has been sold to glassworks at St. Helens, Lancashire. There appear to be considerable reserves below the existing shallow workings. The production recorded since 1892 has come from several localities, but during the four years 1909-1912 the output (amounting to only 618 tons) was entirely obtained at Moelfre, about 2 miles south-east of Llanbedr. Here the bed mined is about 15 inches in thickness, and the ore, which consists of mixed carbonate and silicate, contains from 30 to 32 per cent. of manganese. The weathered parts were richer, but have been worked out. There are still large quantities of unaltered ore at Moelfre, but high working costs appear to prohibit the mining of this deeper and harder material to any large extent.

Derbyshire.—A few hundred tons of wad have been obtained at Brownedge, near Winster, in this county, the ore occurring in flats, pipes, and pockets in the Carboniferous Limestone, but so irregularly as not to permit of systematic working. The method of mining is to sink a shallow shaft and work the mineral from this as far as practicable. The wad occurs with ochre and some barytes, and the small quantity raised is carted to the Via Gellia colour works, near Matlock, although the material is inferior in quality to that imported for such use. Some 10 tons of wad might be raised weekly near Winster, and the mineral is said to occur at other localities.

West of England.—Deposits of manganese ore are often found in East Cornwall and North Devon in connection with very dark and somewhat hard slates, the ore occurring mostly in beds or veins as peroxide, associated with much iron and silica, but also as carbonate and silicate. The peroxide is most

abundant in the Carboniferous slates and shales to the north of Tavistock, Devon, where it occurs in the form of interbedded lenticular deposits.* Pyrolusite and rhodonite were formerly produced in considerable quantities in the neighbourhood of Launceston (East Cornwall) and Brenton Tor (Western Devon). A nearly vertical lode of manganese ore, varying in width from a few inches to several feet, was worked for many years at Upton Pyne and Newton St. Cyres, east of Dartmoor. The best portions of this lode are stated to have contained large pockets of pyrolusite, but wad was found near the surface, and in some places there were considerable masses of psilomelane. In 1872, the Newton St. Cyres mine was re-opened, and from that year to 1879 produced 1,260 tons of ore, value £5,465. The price of the ore subsequently fell to £1 per ton, and, although the lode was reported to be fully 10 feet in width at a depth of only 18 feet below the surface, working became unremunerative.† Considerable quantities of manganese peroxide have also been met with in the Ruther's (Ruthvos) Mine, on Tregoss Moor. While many of these deposits are still unexhausted, they cannot be worked profitably at present prices for the product.

From about the middle of last century, a lode containing manganiferous spathic iron-ore was worked for a number of years at Raleigh's Cross, in the Brendon Hills, West Somerset. The ore, which is stated to have contained about 12½ per cent. of manganous oxide, was used by the Ebbw Vale Iron Company for making spiegeleisen.

Scotland and Ireland.—The manganese ore deposits of these two countries are of little or no economic importance.

Production of Manganese Ore in the United Kingdom.

(Figures supplied to the Bureau by the Chief Inspector of Mines, Home Office.)

Year.	Carnarvonshire.		Merionethshire.		Total.		
						Value.	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Total.	Per ton.
		£		£		£	s. d.
1913 ...	5,291	3,977	102	95	5,393	4,072	15 1·2
1914 ...	3,313	2,804	124	127	3,437	2,931	17 0·7
1915 ...	4,585	4,585	55	55	4,640	4,640	20 0
1916 ...	3,372	3,623	1,768	2,397	5,140	6,020	23 5·1
1917 ...	6,093	8,640	3,849	7,235	9,942	15,875	31 11·2
1918 ...	10,481	19,222	6,975	14,091	17,456	33,313	38 2·0
1919 ...	6,912	15,246	5,166	13,865	12,078	29,111	48 2·5

* J. H. Collins ; Observations on the West of England Mining Region : Plymouth, 1912.

† *Ibid.*

Consumption of Manganese Ore in the United Kingdom.

The annual consumption of manganese ore in the United Kingdom during the period under review cannot be stated with precision in the absence of information as to stocks on hand at the end of 1912 and subsequent years; but the following table showing the annual domestic production, imports and exports of that ore, and the net amount retained in the country, may be regarded as roughly indicating the consumption. The exported ore consisted entirely of Colonial and Foreign produce.

Year.	Domestic Production.*	Imports (Colonial and Foreign).			Total of Domestic Production and Net Imports.
		Gross.†	Less Exported.†	Net.	
	Long tons.	Long tons.	Long tons.	Long tons.	Long tons.
1913 ...	5,393	601,177	9,959	591,218	596,611
1914 ...	3,437	479,435	7,013	472,422	475,859
1915 ...	4,640	372,724	288	372,436	377,076
1916 ...	5,140	440,659	35	440,624	445,764
1917 ...	9,942	331,264	116	331,148	341,090
1918 ...	17,456	365,606	512	365,094	382,550
1919 ...	12,078	264,800	8,755	256,045	268,123

* Home Office Statistics.
† Annual Statement of Trade of the United Kingdom.

By far the greater part of the imported ore was consumed in the production of ferro-alloys, chiefly ferro-manganese, the remainder being used in connection with basic pig manufacture. According to F. H. Hatch,* 15 per cent. of the consumption in 1917 was used for the latter purpose.

During 1913, the last year of normal conditions before the war, the quantities of manganese ore received in the United Kingdom from the principal exporting countries, with the percentages of the total represented in each case, were as follows :—

Country of Origin.	Quantity (long tons).	Per cent. of total.
British India	308,790	51·36
Russia	241,894	40·24
Portuguese India	24,710	4·11
Brazil	18,792	3·13
Spain	3,919	0·65
Other (Foreign) Countries ...	3,072	0·51
Total	601,177	100·00

* The Iron and Steel Industry, 1914–1918; London, 1919, 126.

The following table shows the quantity and value of the imports of manganese ore received in the United Kingdom from various countries during the period under review :—

Imports of Manganese Ore into the United Kingdom.

(Values *c.i.f.* U.K. Port.)

(Annual Statement of Trade of the United Kingdom.)

From	1913.	1914.	1915.	1916.	1917.	1918.	1919.
	Quantity (long tons).						
Gold Coast	—	—	—	2,711	21,720	29,510	24,410
British India	308,790	225,086	348,954	421,443	300,500	324,338	226,887
Other British Possessions	—	—	60	144	128	4,261	5,747
Total from British Possessions.	308,790	225,086	349,014	424,298	322,348	358,109	257,044
Germany	307	188	—	—	—	—	—
Russia	241,894	177,646	—	—	2,137	2,231	6,257
Spain	3,919	3,596	8,856	2,809	1,710	816	363
Japan (including Formosa and leased territories in China).	—	—	70	530	1,937	1,449	394
Portuguese Possessions in India.	24,710	20,275	250	13,011	3,128	2,541	708
Brazil	18,792	46,494	14,515	—	—	—	—
Other Foreign Countries	2,765	6,150	19	11	4	460	39
Total from Foreign Countries.	292,387	254,349	23,710	16,361	8,916	7,497	7,756
TOTAL	601,177	479,435	372,724	440,659	331,264	365,606	264,800
	Value (£).						
Gold Coast	—	—	—	13,553	149,868	235,632	184,624
British India	708,125	507,314	1,085,849	2,200,778	2,052,525	2,957,611	1,743,527
Other British Possessions	—	—	232	2,249	1,751	41,518	32,821
Total from British Possessions.	708,125	507,314	1,086,081	2,216,580	2,204,144	3,234,761	1,960,972
Germany	1,823	1,055	—	—	—	—	—
Russia	463,151	323,297	—	—	63,142	80,652	146,747
Spain	13,617	10,268	26,725	19,169	15,503	9,339	2,493
Japan (including Formosa and leased territories in China).	—	—	670	8,498	48,272	47,824	11,053
Portuguese Possessions in India.	55,255	44,850	500	77,935	22,084	22,006	5,971
Brazil	46,227	101,825	66,514	—	—	—	—
Other Foreign Countries	6,915	13,045	268	218	35	2,873	721
Total from Foreign Countries.	586,988	494,340	94,677	105,820	149,036	162,694	166,985
TOTAL	1,295,113	1,001,654	1,180,758	2,322,400	2,353,180	3,397,455	2,127,957
Average value per ton ...	*s. d.* 43 1	*s. d.* 41 9·4	*s. d.* 63 4·3	*s. d.* 105 4·8	*s. d.* 142 0·9	*s. d.* 185 1·2	*s. d.* 160 8·7

The imports of manganese ore into the United Kingdom in 1920 have been reported as 452,613 tons.

Imports of Manganiferous Iron-Ore into the United Kingdom.

(Values *c.i.f.* U.K. Port.)

(Annual Statement of Trade of the United Kingdom.)

From	1913.	1914.	1915.	1916.	1917.	1918.	1919.
	Quantity (long tons).						
Total from British Possessions (British India)...	—	2,717	5,720	3,994	—	—	20,288
Greece	13,499	17,859	17,986	—	—	2,533	4,500
Spain	188,196	120,249	83,639	47,137	101,323	99,886	76,145
Algeria	3,797	16,857	30,334	30,861	28,177	18,109	21,796
Other Foreign Countries ...	6,152	7,811	1,289	—	5,561	3,078	5,104
Total from Foreign Countries ...	211,644	162,776	133,248	77,998	135,061	123,606	107,545
TOTAL ...	211,644	165,493	138,968	81,992	135,061	123,606	127,833
	Value (£).						
Total from British Possessions (BritishIndia) ...	—	6,140	15,423	17,551	—	—	70,491
Greece	10,056	11,448	24,045	—	—	3,927	8,100
Spain	149,632	97,501	98,528	77,356	190,186	192,368	159,611
Algeria	3,757	13,647	36,311	51,468	50,919	30,193	39,450
Other Foreign Countries ...	9,050	11,572	2,191	—	11,398	4,925	13,262
Total from Foreign Countries ...	172,495	134,168	161,075	128,824	252,503	231,413	220,423
TOTAL ...	172,495	140,308	176,498	146,375	252,503	231,413	290,914
Average value per ton	*s. d.* 16 3·6	*s. d.* 16 11·5	*s. d.* 25 4·8	*s. d.* 35 8·5	*s. d.* 37 4·7	*s. d.* 37 5·3	*s. d.* 45 6·2

Exports of Manganese Ore from the United Kingdom (Colonial and Foreign Produce).

(Values *f.o.b.*)

(Annual Statement of Trade of the United Kingdom.)

To	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Total to British Possessions.	1,195	88	84	10	—	—	40
Value (£)	3,433	348	1,270	82	—	—	1,400
Belgium	8,440	6,450	—	—	—	—	6,412
France	—	—	128	—	77	512	330
Netherlands ...	—	—	15	—	35	—	1,243
United States ...	309	412	—	—	—	—	—
Other Foreign Countries.	15	63	61	25	4	—	730
Total to Foreign Countries.	8,764	6,925	204	25	116	512	8,715
Value (£)	34,786	28,884	3,022	755	3,532	22,232	98,270
TOTAL—tons ...	9,959	7,013	288	35	116	512	8,755
TOTAL—value (£)	38,219	29,232	4,292	837	3,532	22,232	99,670
Average value per ton	*s. d.* 76 9	*s. d.* 83 4·4	*s. d.* 298 0·6	*s. d.* 478 3·4	*s. d.* 608 11·6	*s. d.* 868 5·2	*s. d.* 227 8·2

Exports of Manganiferous Iron-Ore from the United Kingdom (Domestic Produce).

(Values *f.o.b.*)

(Annual Statement of Trade of the United Kingdom.)

To	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Total to British Possessions.	15	8	5	—	—	—	—
Value (£)	120	107	20	—	—	—	—
United States ...	—	1,496	—	—	—	—	—
Other Foreign Countries.	19	2	—	10	25	—	1,455
Total to Foreign Countries.	19	1,498	—	10	25	—	1,455
Value (£)	68	10,868	—	33	192	—	11,654
TOTAL—tons ...	34	1,506	5	10	25	—	1,455
TOTAL—value (£)	188	10,975	20	33	192	—	11,654
Average value per ton	*s. d.* 110 7·1	*s. d.* 145 9·0	*s.* 80	*s.* 66	*s. d.* 153 7·2	—	*s. d.* 160 2·3

Production of Ferro-manganese, Spiegeleisen, &c., in the United Kingdom.

Statistics showing the annual production of ferro-manganese, spiegeleisen, silico-manganese and silico-spiegel in the United Kingdom during the period under review are not available, except for the years 1917 and 1918, in which the production was as follows :—

(Figures supplied to the Bureau by National Federation of Iron and Steel Manufacturers.)

Alloy.	Quantity (long tons). 1917.	1918.
Ferro-manganese	162,684	164,103
Spiegeleisen	33,208	34,217
Silico-manganese	98,711	49,640
Silico-spiegel	3,587	3,015
Total	298,190	240,975

The total production of these alloys in 1920 has been reported by the same authority as 239,000 tons (approx.).

*Imports of Spiegeleisen, Ferro-manganese and Ferro-silicon into the United Kingdom.**

(Values *c.i.f.* United Kingdom Port.)

(Annual Statement of Trade of the United Kingdom.)

From	Quantity (long tons). 1913.	1914.	1915.	1916.	1917.	1918.	1919.
Total from British Possessions.	—	—	25	288	—	6,356	810
Value (£) ...	—	—	625	6,619	—	350,133	20,747
France	2,701	2,124	4,109	492	—	—	—
Germany	18,202	9,471	—	—	—	—	—
Netherlands ...	50	—	—	—	—	—	—
Norway	1,475	2,230	3,117	5,077	2,099	5,097	1,757
Sweden	5,992	5,472	8,704	5,635	746	2,067	27
United States ...	2,647	2,757	2,503	12,870	10,795	11,472	1,095
Other Foreign Countries.	867	654	30	60	—	—	—
Total from Foreign Countries.	31,934	22,708	18,463	24,134	13,640	18,636	2,879
Value (£) ...	172,679	149,387	218,708	519,228	520,652	831,962	91,110
TOTAL—tons ...	31,934	22,708	18,488	24,422	13,640	24,992	3,689
TOTAL—value (£)	172,679	149,387	219,333	525,847	520,652	1,182,095	111,857
Average value per ton.	*s. d.* 108 1·8	*s. d.* 131 6·9	*s. d.* 237 3·2	*s. d.* 430 7·6	*s. d.* 763 5·0	*s. d.* 945 11·7	*s. d.* 606 5·2

The total imports of these alloys into the United Kingdom in 1920 have been reported as 16,116 tons.

* The imports of the different alloys are not separately stated.

*Exports of Spiegeleisen, Ferro-manganese and Ferro-silicon from the United Kingdom (Domestic Produce).**

(Values *f.o.b.* U.K. Port.)

(Annual Statement of Trade of the United Kingdom.)

To	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1817.	1918.	1919.
Canada	9,996	3,360	8,349	9,587	7,485	15,419	1,505
Other British Possessions	2,439	779	4,015	494	602	253	611
Total to British Possessions.	12,435	4,139	12,364	10,081	8,087	15,672	2,116
Value (£)	119,454	34,988	176,304	249,813	241,362	648,329	73,915
Belgium	11,355	6,185	—	—	—	—	29,379
France	9,600	3,110	6,939	11,661	16,916	15,474	11,365
Germany	3,553	3,561	—	—	—	—	1,384
Italy	4,495	3,123	9,807	10,849	3,411	2,985	3,171
Netherlands	1,724	1,572	168	105	—	—	754
Russia	3,577	1,355	817	1,454	1,397	—	160
Spain	3,624	1,939	4,534	4,355	2,234	335	2,055
Sweden	6,232	3,904	2,595	2,505	2,203	966	2,720
United States	116,660	79,498	60,882	81,188	57,760	29,821	43,803
Japan	3,599	1,785	3,346	4,163	1,484	50	790
Other Foreign Countries	2,065	1,617	1,486	1,040	985	51	952
Total to Foreign Countries.	166,484	107,649	90,574	117,320	86,390	49,682	96,533
Value (£)	1,511,261	915,189	1,190,151	2,522,471	2,350,909	1,535,559	2,468,285
TOTAL—tons	178,919	111,788	102,938	127,401	94,477	65,354	98,649
TOTAL—value (£) ...	1,630,715	950,177	1,366,455	2,772,284	2,592,271	2,183,888	2,542,200
Average value per ton...	*s. d.* 182 3·4	*s. d.* 169 11·9	*s. d.* 265 5·9	*s. d.* 435 2·5	*s. d.* 548 9·1	*s. d.* 668 3·9	*s. d.* 515 4·8

The total exports of these alloys from the United Kingdom in 1920 have been reported as 117,386 tons.

* The quantities of the different alloys exported are not separately stated, but it is known that the shipments to the United States, Canada, France, and Italy consisted mainly, if not wholly, of ferro-manganese.

Exports of Spiegeleisen, Ferro-manganese and Ferro-silicon from the United Kingdom (Colonial and Foreign Produce).

(Values *f.o.b.*)

(Annual Statement of Trade of the United Kingdom.)

To	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Total to British Possessions ...	—	—	—	6	13	26	—
Value (£) ...	—	—	—	276	725	1,758	—
France	—	—	522	—	596	609	—
Japan	—	—	—	101	—	—	269
Other Foreign Countries ...	56	59	134	111	150	3	—
Total to Foreign Countries ...	56	59	656	212	746	612	269
Value (£) ...	415	581	9,999	7,123	19,100	15,379	17,000
TOTAL—tons	56	59	656	218	759	638	269
TOTAL—value(£)	415	581	9,999	7,399	19,825	17,137	17,000
Average value per ton	*s. d.* 148 2·6	*s. d.* 196 11·4	*s. d.* 304 10·2	*s. d.* 678 9·7	*s. d.* 522 4·8	*s. d.* 537 2·5	*s. d.* 1,263 11·3

Egypt.

Sinai Peninsula.—Deposits of manganiferous ore of considerable size, in the southern half of West-Central Sinai, have been described by J. Ball.* These deposits, which were discovered in 1898 by T. Barron, of the Geological Survey, Egypt, are found at one particular geological horizon, viz., the base of the Carboniferous Limestone series. (Thin beds of ore are also occasionally seen at the top of the limestone, and in the neighbouring sandstone, but these are not of economic importance.) Though not true beds, the ore deposits possess in general a marked bed-like character, extending for considerable distances along the same level. The principal localities in which the deposits have been found are: (1) at Gebel Um Rinna; (2) in and near the Wadi Kharig; (3) on both sides of Wadi Baba near Bir Rekis; (4) in Wadi Nasib; (5) round the heads of Wadi Abu Hamata and its tributaries; (6) in the hills of the Um Bogma district; and (7) in the neighbourhood of Bir Um Hamd. The most important occurrences are those of the Um Bogma district, which are now being worked on a commercial scale by the Sinai Mining Co., Ltd.

* The Geography and Geology of West-Central Sinai; Ministry of Finance, Egypt, Survey Department, Cairo, 1916.

The ores of the Um Bogma district occur as irregular deposits, with a strong tendency to tabular and lenticular forms, at the base of the Carboniferous Limestone, the principal deposits cropping out in the faces of the steep scarps that bound four groups of irregular plateau-like hills, named the Central, North, East, and South Hills respectively.

A bed-like deposit of ore, averaging about 6½ feet in thickness and attaining as much as 13 feet in places, extends through the greater portion of the Central Hills, the ore being mostly of a rather soft character, varying from almost pure pyrolusite to an ochreous hæmatite, but there is also some psilomelane. The deposits are generally thickest and richest in manganese near the faces of the scarps, becoming more ferruginous farther in. This general richness at the scarp faces can be correlated with proximity to faults, suggesting that faulting has had something to do with the genesis of the deposits.

In the East Hills, the ore bed attains a maximum thickness of 13 feet, and contains numerous hard patches very rich in manganese.

The North Hills do not appear to have been prospected so thoroughly as the Central and East, but the ore deposits can be traced around almost continuously.

Highly ferruginous beds, with patches of hard and soft manganese ore, can be traced around a large portion of the South Hills; but excavations show that the ore deposits here are thinner and poorer in manganese than those of the other groups of hills. It appears, moreover, that they are largely peripheral and do not persist through the hill mass.

Engineers' reports show estimated ore reserves approximately as follows: positive ore, 2,512,000 tons; probable, 3,069,000 tons; possible, 6,267,000 tons; total, 11,848,000 tons, average value 32·3 per cent. manganese, and 25 per cent iron. The following analysis is stated to represent the average of 211 samples:—

	Per cent.
Manganese	32·36
Iron	25·08
Silica	2·79
Sulphate of barium	3·29
Phosphorus	0·126

It is estimated that, when shipping at the proposed rate of 300,000 tons per annum, the grade of the ore could be maintained by selection at 35 per cent. manganese and 23 per cent. iron; also that a limited quantity of ore averaging 47·2 per cent. manganese and 7·35 per cent. iron could be produced by selection without materially affecting the average-grade ore of the mines, which latter will be marketed for use in the production of basic steel. The port of shipment is Abu Zenima.

Operations were suspended at the outbreak of the war. In February, 1915, extensive damage was done by Turkish troops to the Company's buildings and plant at Abu Zenima, and no shipments of ore could be made until October, 1918. The quantity

of ore exported during that year is stated by the company to have amounted to 9,336 tons. Shipments in 1919 amounted to 42,970 tons, and it is expected that the tonnage for 1920 will largely exceed that figure. A special effort was made during the war to ship ore with the highest possible percentage of manganese, these consignments not representing the grade of ore under ordinary working conditions. Recent cargoes are stated to have yielded, on dried ore, 37 per cent. manganese and 18 per cent. iron, the amount of silica being under 3 per cent. Of the ore shipped to date, about 70 per cent. is stated to have been delivered to continental Europe, and the remaining 30 per cent. to the United Kingdom.

West Africa.

Gold Coast.—Large deposits of manganese ore discovered by A. E. Kitson, Director of the Geological Survey, at Dagwin, near Taquah, in the Wassaw district, in May, 1914, have since been exploited by the Wassaw Exploration Syndicate and the Fanti Consolidated Mines, Ltd. The following information concerning these deposits is taken from an account by S. H. Ford.*

Work was commenced in June, 1916, and a first shipment of 174 tons was made in September of that year. The Seccondee-Coomassie railway runs through the Dagwin Concession and, at about 33 miles from the port of Seccondee, ore is found some 200 yards from the line. Massive outcrops, consisting generally of ore containing from 42 to 53 per cent. of manganese but with patches where the material is too poor to be valuable, are practically continuous on the crest of a ridge running north-east for about $2\frac{1}{2}$ miles from the 33-mile post. Similar ore has been found still farther to the north-east and half-a-mile inside the adjoining Insuta Concession. The ore shipped so far from the Dagwin Concession has been recovered from a detrital deposit lying on the slopes of the main ridge, this material being the result of the weathering of the main outcrop on the crest. The detritus consists of boulders and nodules of ore embedded in clay, the thickness of the surface deposit varying from 18 inches to 15 feet. The overburden and clay, and any ore obviously too high in iron for shipment, are thrown behind on to the lower slopes of the hill, while the embedded nodules and the boulders, after blasting, are stacked for sampling and assay. One of the largest outcrops on the crest of the ridge, about 500 yards north-east of the 33-mile post, extends apparently for about 400 feet along the strike, and has a width at right angles to this of about 70 feet. An adit about 220 feet below the crest in this locality passed through manganese ore in three places, one showing solid ore for a stretch of 60 feet. Where not in ore, the adit passes through light-coloured clay or altered shales dipping from 60 degrees to 70 degrees to the south-east. A main drive was being put in on this section of the ore-body at the date of this account, and had been carried 100 feet in solid ore, crosscuts showing the width to be maintained. The ore exposed in this

* The Mining Magazine, London, 1917, *17*, 271.

adit and connected workings assayed from 46 to 47 per cent. manganese.

Although pyrolusite is occasionally found on the Dagwin Concession, the mineral generally is psilomelane. Broadly speaking, the percentage of manganese plus iron is fairly constant at 55 to 56 per cent.; thus, with 53 per cent. of manganese, there is about 3 per cent. of iron; with 45 per cent. of manganese, about 9 to 10 per cent. of iron. In clean ore the silica and phosphorus are low. Up to July 31st, 1917, shipments amounted to 20,600 tons of ore, the average percentage composition of which was as follows:—manganese, 52; iron, 4·6; silica, 4; phosphorus, 0·11.

The Company's report for the year 1918 showed that the output of manganese ore had been restricted by want of shipping, but it was expected that shipping facilities would be gradually improved. The outstanding difficulties were the railway rate and terminal charges (8*s*. 6*d*. per ton over a distance of 33½ miles) and insufficient lighterage at Seccondee. With lower railway rates and adequate shipping facilities, 90,000 tons of ore could be produced and shipped per annum, and, when various pending arrangements were completed, this quantity could be largely increased.

The manganese ore deposits on the Dagwin Extension Concession have been reported as extending for about 2¾ miles, divided into zones, on which development is being carried out. At the northern end of this property a deposit is stated to have been proved over a length of about 2,200 feet, with ore at the outcrop averaging 50 per cent. manganese, the thickness of the deposit being probably over 30 feet. In the second zone, the deposit is said to be about 1,800 feet in length, and in the third about 1,400 feet; while a parallel range to the east of the third zone is stated to contain extensive deposits. It is estimated by the owners that the detrital ore alone, lying on the surface and down to a shallow depth, on the Dagwin Extension, amounts to nearly 3 million tons.

Production of Manganese Ore in Gold Coast Colony.

(Exports—Values *f.o.b.* Seccondee.)

(Govt. of the Gold Coast, Annual Reports on the Mining Industry.)

Year.	Dagwin Concession.			Dagwin Extension Concession.			Total.		
	Quantity (long tons).	Estd. value.		Quantity (long tons).	Estd. value.		Quantity (long tons).	Estd. valne.	
		Total.	Per ton		Total.	Per ton.		Total.	Per ton.
		£	*s. d.*		£	*s. d.*		£	*s. d.*
1916 ...	—	—	—	4,258	—	—	4,258	—	—
1917 ...	7,953	13,391	33 8·1	23,183	38,216	32 11·6	31,136	51,607	33 1·8
1918 ...	12,344	46,638	75 6·8	17,948	55,981	62 4·6	30,292	102,619	67 9·0
1919 ...	11,051	21,194	38 4·3	24,138	29,591	24 6·2	35,189	50,785	28 10·4

In the report of the Fanti Consolidated Mines, Ltd., for 1918, it is stated that, in addition to the ordinary ore shipped in bulk, containing about 51 per cent. of manganese and 5 per cent. of iron, several consignments of rich ore, containing about 86 to 87 per cent. of manganese dioxide and about 1 per cent. of iron, had been bagged and shipped. In the report for 1920 it is stated that the quantity of manganese ore shipped in that year was 41,546 tons, and that it is intended to develop and equip the Company's property for the production of 200,000 tons of ore per annum.

Figures compiled by the United States Bureau of Foreign and Domestic Commerce show that 1,194 tons of manganese ore, valued at $15,587 (at 4*s*. 2*d*. to the $=£3,247) were received in the United States from British West Africa (presumably the Gold Coast Colony) in the year 1919.

Union of South Africa.

Manganese ores occur in the Union, according to T. G. Trevor,* in three main classes of deposit :—

(1) Fissure veins, and enrichments on their outcrops due to weathering.

(2) Connected with the dolomites and Moodies series :
  (*a*) Diffused in the dolomites.
  (*b*) Irregular deposits in the dolomites and Moodies series.
  (*c*) Bedded deposits in the dolomite and Moodies series.

(3) Weathering products derived from dolomites.

By far the most important deposits of manganese ore yet opened up in the Union are those of class (3), as proved in the Krugersdorp District of the Transvaal.

Cape Province.—Deposits of class (1) are fairly numerous in the south-west Districts, occurring at Hout's Bay, Constantia Nek, Kogel Bay (in False Bay), Botha's Halt near Worcester, Du Toit's Kloof near Wellington, French Hoek and Caledon. These have been investigated by A. B. Welsh.† In all cases the outcrops were very much larger and richer than the actual veins, showing a distinct enrichment at the surface due to weathering. The ores contain a comparatively low percentage of manganese and are rather high in phosphorus; the quantities available are generally not large, and costs of mining and transport would be heavy, vein-mining being required except in the case of the Caledon deposit, which in many places has no overburden and could be worked by open quarrying. Approximate

* Manganese; The South African Journal of Industries; Pretoria, Transvaal, 1919, *2*, 35.

† Report on Manganese Deposits of S.W. Districts of Cape Province; Dept. of Mines and Industries, Union of S. Africa, Pretoria, 1917.

analyses of clean, hand-sorted ore from the three most important occurrences show the following percentages :—

——	Manganese.	Iron.	Silica.	Phosphorus.
Caledon	38	16 to 20	6·5	0·378
Du Toit's Kloof	40	13 to 22	0·75 to 4	0·47 to 0·57
Hout's Bay	30	9 to 16	6·00 to 12	0·47 to 0·66

In every case the phosphorus is excessively high, and, as at present known, these deposits are not sufficiently large or rich to be of economic importance.

Transvaal.—Deposits derived from the weathering of dolomites have been opened up on several "farms" in the Krugersdorp District. The deposit on Elandsvlei No. 23, which is typical of its class, has been described by the Inspector of Mines for the District. The geological formation is Black Reef Series. Where the deposit occurs there is a covering of red soil, under which lie remnants of dolomite formation in the form of disintegrating chert mixed with clay, lime, and ironstone, the manganese mineral occurring in this mixture in nodules varying from quite small size up to 12 or 15 inches in length and averaging about 6 inches. The ore occurs chiefly as dioxide in the form of pyrolusite or psilomelane, as a pseudomorph after oxide of iron, chert, and shale, every nodule having a certain amount of yellow oxide of iron attached to it even after dressing. The workings cover an area of about $\frac{3}{4}$ of a mile by half a mile, and consist of shallow pits varying in depth from a few inches to a maximum in a few cases of about 10 feet, depending chiefly on the thickness of the red soil covering. In some places boulders containing manganese lie on the surface. Rich pockets have been found in three localities on the farm, these being probably more than 100 yards in cross measurement, and it is expected that other similar local enrichments will be discovered. Analyses of cobbed ore awaiting shipment showed about 59 to 63 per cent. of manganese dioxide, hand specimens running as high as 92·5 per cent. It is believed that an output of marketable manganese ore could be obtained from the Krugersdorp and similar deposits in the Union sufficient for all possible domestic needs. The areas in the Transvaal and Bechuanaland where the dolomites lie almost horizontally and have suffered intense denudation are large, and Trevor considers it likely that deposits similar to that described will be found in many places when sought for.

An impure wad was formerly mined for a short time on the farm Kromdraai, in the Krugersdorp District, the material being used in the earlier days of the Usher-Adair cyaniding process.

On the farms Zwartkrans No. 67 and Sterkfontein No. 68, in the same district, numerous pits sunk are stated* to have made it clear that the manganese ore occurrences in those areas are in

* Manganese in the Transvaal ; The S.Af. Min. and Eng. Journ. : Johannesburg, 1919, *28*, 527.

the form of veins intersecting the strata more or less along the bedding planes so far as direction goes, but forming generally a network of closely intersecting seams with occasional pockets and lenses of fairly large size. Wherever pits have been put down upon the surface of these two farms the crushed cherty rock with numerous seams of high-grade manganese ore is usually in evidence, while also there is a vast accumulation of loose ore and nodules in the overlying detritus. In addition to ore suitable for metallurgical and chemical uses, a large supply of manganiferous earth and other natural pigment earth of good quality is stated to exist on these farms. A company has been formed to exploit the deposits. Samples of the ore assayed in Johannesburg showed from 47·59 to 59·4 per cent. of manganese, and generally less than one per cent. of iron, the percentages of phosphorus and silica being well below the penalty limits.

At Derdepoort, near Pretoria, a small vein of manganese ore (pyrolusite), dipping at a high angle, shows signs of permanence (Trevor, *loc. cit.*). The outcrop had been worked for about 40 yards to a maximum depth of 35 feet by the end of 1918, the width of the vein at bottom being about 4 feet. A bulk sample assayed in England yielded the following percentages after drying: manganese, 56·10; iron, 2·63; silica, 1·70; phosphorus, 0·135. The ore was reported to be good hard mineral, and, if its quality holds, the deposit should be capable of supplying a sufficient quantity of high-grade ore for the electrical and kindred requirements of the Union. A few tons of manganese ore are being mined per month near Pretoria for use in the cyanide works of the Rand.

Other deposits, usually poor in manganese and of no great extent, occur elsewhere in the Transvaal.

Natal.—Investigations of occurrences of manganese ore in this Colony (chiefly pyrolusite, with wad and psilomelane) have shown that the material, even when very carefully hand-picked, cannot be brought up to a 50 per cent. grade; and, in view of the high cost of working the deposits and the heavy transport and freight charges that shipments would have to meet, the establishment of a manganese industry in Natal is regarded as impracticable.*

Production of Manganese Ore in the Union of South Africa.†

No production of manganese ore in the Union is recorded for the years 1913-16. The figures for later years are as follows, no values being stated :—

Year.	Quantity (long tons).		
	Transvaal.	Natal.	Total.
1917	206	42	248
1918	559	262	821
1919	71	5	76

* F. H. Hatch; Report on Mines and Mineral Resources of Natal, London, 1910.
† Annual Reports, Mines Department, Union of South Africa: Pretoria.

During the same years, the total actual sales of manganese ore in the Union were as follows :—

Year.	Transvaal.			Natal.			Total.		
	Quantity (long tons).	Value.		Quantity (long tons).	Value.		Quantity (long tons).	Value.	
		Total.	Per ton.		Total.	Per ton.		Total.	Per ton.
		£	*s. d.*		£	*s. d.*		£	*s. d.*
1917 ...	79	536	135 8·4	31	105	67 8·9	110	641	116 6·5
1918 ...	407	1,701	83 7·0	79	264	66 10·0	486	1,965	80 10·4
1919 ...	138	776	112 5·6	—	—	—	138	776	112 5·6

The value of the total production of manganese ore in the Union to the end of 1919 is almost negligible, the figures being as follows :—Transvaal, £3,013 ; Cape Province, £179 ; Natal, £549 ; Total, £3,741. The ore produced in the Transvaal during 1919 contained 48·67 per cent. of manganese.

The production of manganese ore in the Union in 1920 was only about 60 tons.

Manganese Ore Exported from the Union of South Africa.

(Values *f.o.b.* Port of Shipment.)

(Annual Statements of Trade and Shipping, Union of South Africa.)

Year.	Quantity (long tons).	Value.	
		Total.	Per ton.
		£	*s. d.*
1913	20	116	116
1914	49	99	40 4·9
1915	73	371	101 7·7
1916	2	21	210
1917	5	46	184
1918	95	518	109 0·5
1919	144	453	62 11

Figures compiled by the U.S. Bureau of Foreign and Domestic Commerce show that 144 long tons of manganese ore, valued at $3,570 (at 4*s.* 2*d.* to the $=£744), were received in the United States from British South Africa (presumably the Union of South Africa) in the year 1919.

Canada.

The following account of the manganese ore resources of Canada is abstracted from the Final Report of the work of the Munition Resources Commission, Canada, covering the period November, 1915—March, 1919.

New Brunswick and Nova Scotia.—At present there is no manganese mine in the Maritime Provinces developed to the point of steady production. Practically all the recent tonnage has been derived from small mines at New Ross, Lunenburg County, Nova Scotia. These produced only from 1 to 2 tons daily of very high grade ore, all of which was exported to the United States and sold to glass and dry-cell manufacturers at prices ranging from $120 to $175 per ton.

There is no production in New Brunswick or Nova Scotia of ore suitable for the manufacture of ferro-manganese, but the work of the Commission has disclosed the possibility of securing some tonnage of low-grade ores capable of concentration. Bog-manganese deposits found in New Brunswick contain some ore suitable for the production of spiegeleisen.

A deposit of banded manganese ore in sandstone has been prospected to some extent at Walton, Hants County, Nova Scotia. This ore contains about 15 per cent. of manganese, and experiments have demonstrated that it can be concentrated to a product containing over 45 per cent. of manganese and that high-grade ferro-manganese can be made from this product in electric furnaces.

Prof. J. C. Gwillim, in his Report to the Munition Resources Commission of August 23rd, 1917, states that two varieties of manganese ore are found in the Maritime Provinces: (1) the hard ores, pyrolusite, manganite and psilomelane, which occur usually as reniform lumps or streaks, and sometimes as large pockets containing several hundred tons, in the reddish shales and the conglomerates, and in the grey limestone strata of the Lower Carboniferous rocks; (2) the soft bog-manganese ores, or wad, which are deposited by springs and occur in patches on the surface, varying in extent from an acre or less to many acres and in depth from a few inches to 20 feet. Usually these bog ores, which are found at many places, especially in New Brunswick, are very wet and contain much organic matter, being covered with moss, grass or even large trees, where the springs have ceased to saturate the ground. Such ores on drying at 100°C. lose over 50 per cent. of their weight, and may contain from 10 to 55 per cent. metallic manganese. They amount in the aggregate to possibly several thousand tons, but at normal prices of, say, $12 per ton, offer little encouragement for working up into a saleable product.

Examples of the hard ores are found at Shepody Mountain, Markhamville, Jordan Mountain and Quaco Head in New

Brunswick, and at Loch Lomond, Cheticamp, Walton, and other places in Cape Breton and Nova Scotia. A local variation is found in the New Ross district of Nova Scotia, the only producing locality at the present time, where hard ore occurs in vein formation in a biotite-granite. In the past, such deposits have been mined until some particular local enrichment was worked out, very little systematic search being made for other pockets that probably occur on the same geological horizon. These hard ores have commanded a price in normal times of $60 per ton, for the chemical, dry cell, and glass industries, and were worth considerably more than $100 per ton at the date of the Commission's Final Report. There are not yet in evidence any deposits of manganese ore in eastern Canada that offer a reasonable supply for the ferro-manganese industry in competition with foreign ores.

Alberta and British Columbia.—Certain manganiferous deposits from calcareous springs in Southern Alberta, examined in 1917, were reported to contain less than 10 per cent. of manganese.

An occurrence of manganese ore near Kaslo, on Kootenay lake, British Columbia, examined for the Commission, gave indications at first of a small tonnage of 40 per cent. ore; but subsequent work disclosed more ore, and several hundred tons have been exported to the United States.

In 1918, a new discovery of manganese ore near Cowichan lake, on Vancouver Island, was reported to look promising for merchantable metallurgical ore. It occurs as a mixture of secondary oxides, principally pyrolusite, psilomelane and manganite, derived from the alteration of rhodonite, which occurs in strong outcrops throughout a manganiferous area extending for a distance of over 25 miles in a north-westerly direction on the north side of Cowichan lake.

In 1919, nearly 600 tons of manganese ore, containing more than 50 per cent. of manganese and less than 20 per cent. of silica, was shipped from the Hill 60 property on Cowichan lake before the roads became impassable on account of winter rains. An aerial tramway is to be installed, which should enable continuous shipments to be made in future. About 100 tons of high-grade manganese ore was also shipped from the Curle manganese group, near Kaslo. Both shipments went to the Bilrowe Alloys Co., Tacoma, Washington.*

The consumption of ferro-manganese in Canada for steel production during the war period was about 1,000 tons monthly, all of which had to be imported from the United Kingdom and the United States, at prices ranging from $200 to over $300 per ton. At the present time there is no production of ferro-manganese in Canada, but the Algoma Steel Corporation, Ltd., at Sault Ste. Marie, Ontario, continues to manufacture spiegeleisen in blast furnaces, and the Electro Metals Ltd., of Welland, Ontario, have commenced the production of silico-manganese in electric furnaces.

* Ann. Rep. of the Minister of Mines, British Columbia, 1919, 24.

Production, Imports and Exports of Manganese Ore and Alloys, Canada.

(Annual Reports Mineral Production of Canada.)

—	1913.		1914.		1915.		1916.		1917.		1918.		1919.	
	Quantity (long tons).	Value per ton.	Quantity (long tons).	Value per ton.	Quantity (long tons).	Value per ton.	Quantity (long tons).	Value per ton.	Quantity (long tons).	Value per ton.	Quantity (long tons).	Value per ton.	Quantity (long tons).	Value per ton.
Production of Ore :		£ s. d.		£ s. d.		£ s. d.		£ s. d.		£ s. d.		£ s. d.		£ s. d.
Nova Scotia ...	—	—	25	9 6 8	45	26 13 4	577	25 8 2	141	21 18 5	—	—	—	—
New Brunswick ...	—	—	—	—	134	5 11 11	277	14 8 5	—	—	—	—	—	—
British Columbia ...	—	—	—	—	—	—	—	—	—	—	393	3 6 1		
Total	—	—	25	9 6 8	179	10 17 11	854	21 16 11	141	21 18 5	393	3 6 1		
Imports :														
Manganese oxide*...	2,310	4 4 9	1,520	5 15 11	1,105	8 16 0	1,045	12 14 4	1,579	12 4 5	954	20 8 3		
Ferro-silicon, spiegeleisen and ferromanganese ...	27,103	7 4 7	19,774	5 15 10	12,284	13 13 10	13,194	29 13 7	11,454	36 18 6	31,504	28 6 6	14,483	
Exports :														
Manganese ore ...	7	0 17 11	27	5 15 9	228	6 5 4	854	21 16 11	165	20 4 10	700	8 13 11		
Ferro-silicon and compounds ...	—	—	4,344†	13 13 7	8,248	13 11 4	20,359	13 16 8	29,654	18 7 9	21,233	26 4 3	20,044	

Values converted into £ sterling at the rate of $1 = 4s. 2d.

* No separate record of Imports of Manganese Ores is kept in the classification of the Customs Department. † For nine months.

The Imports of Ferro-silicon, &c., in 1920 have been reported as 7,172 tons, and the Exports thereof as 22,698 tons.

Ferro-Alloys entered for consumption in Canada, by Countries. Fiscal years ended March 31.

(Annual Reports of Trade of Canada.)

Year.	Ferro-silicon, Spiegeleisen and Ferro-manganese.				
	Quantity (long tons).				
	Great Britain.	Newfoundland and Labrador.	Germany.	United States.	Total.
1913	17,221	—	1,940	1,347	20,508
1914	12,158	67	9,867	3,404	25,496

After 1914, the classification was amended as follows :—

Year.	Spiegeleisen and Ferro-manganese.									Total Quantity (long tons).
	Quantity (long tons).									
	Containing 15 per cent. or less of manganese. (Dutiable.)				Containing over 15 per cent. of manganese. (Free.)					
	Great Britain.	Germany.	United States.	Total.	Great Britain.	India.	France	United States.	Total.	
1915	408	1,713	—	2,121	5,494	—	1	10,137	15,632	17,753
1916	8	—	213	221	6,352	—	—	4,857	11,209	11,430
1917	51	—	434	485	4,876	—	—	5,130	10,006	10,491
1918	120	—	593	713	4,831	—	—	6,641	11,472	12,185
1919	46	—	653	699	9,337	201	—	20,178	29,716	30,415

Newfoundland.

Extensive deposits of low-grade manganese ore have long been known to occur on the north-east coast of this Dominion along the south side of Conception Bay, associated with limestone, near the base of the Cambrian series.* Some testing of these deposits has been done, but regular mining has not yet been attempted. Wad, or bog-manganese, is stated to occur in many localities, but so far no high-grade manganese ore has been discovered. A sample from Conception Bay has been reported as an impure manganite, containing 38·0 per cent. of manganese, 2·0 of iron, 17·56 of silica, and 0·100 of phosphorus.

* J. P. Howley; Mineral Resources of Newfoundland : St. John's, N.F., 1909.

N. C. Dale* has described occurrences of manganese ore near Manuels, Topsail, Long Pond, Chapel Cove and Brigus, on Conception Bay; also occurrences some 50 miles to the north-west on Smith Sound, Trinity Bay; and others about 50 miles to the south-west on Placentia Bay, on the south coast. The manganese minerals and interbedded bands of jasper are stated to form zones from 20 to 30 feet in width in shales and limestones of Lower Cambrian age. There is an exposure of nodular carbonate of manganese in Manuels Brook.

One hundred and sixty-five tons of manganese ore are reported to have been shipped from Newfoundland during the year 1920.

India.

Exploitation of manganese ore deposits in India dates from 1892, when production on a small scale began in the Vizagapatam district, Madras Presidency. Production in the Central Provinces started in 1900.

The Indian manganese ore deposits of economic value can be divided into three main groups—

(1) Deposits associated with a series of manganiferous intrusive rocks known as the *kodurite* series, consisting typically of manganese-garnet, orthoclase felspar, and apatite (phosphate of lime), from which rocks the manganese ores have been formed by the percolation of water carrying carbon dioxide and alkaline carbonates in solution. The depths to which these ores extend is thus probably determined by that of the zone of weathering. Important examples of these deposits occur in Vizagapatam, Madras.

(2) Deposits occurring in rocks of Dharwar age, either as consolidated beds of chemically-deposited manganese dioxide, or associated with the *gondite* series, a group of strongly metamorphosed manganese-silicate rocks resulting from the alteration of manganiferous sediments. Important examples of these deposits occur in Gangpur (Bihar and Orissa), Panch Mahals (Bombay), Jhabua (Central India), and in Balaghat, Bhandara, Chhindwara and Nagpur (Central Provinces).

(3) Deposits occurring on the outcrops of Dharwar rocks as replacement masses formed by the action of manganiferous solutions at and near the surface, modified in some cases by subsequent segregation. Important examples of this class occur in Singhbhum (Bihar and Orissa), Jubbulpore (Central Provinces), Goa (Portuguese India), Bellary and Sandur (Madras), Chitaldroog, Viadur, Shimoga and Tumkur (Mysore).

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* **Manganese deposits of Conception and Trinity Bays (Newfoundland); Bull. Geol. Soc. America, New York, 1914, *25*, 73.**

The following brief accounts of the various known deposits of manganese ore in India are derived mainly from *The Manganese Ore Deposits of India*, by L. L. Fermor (*loc. cit.*).

Descriptions of Deposits.

Central Provinces.

Balaghat District.—The deposits of this district are confined to a belt of country about 75 miles in length and 9 miles in width, stretching in a west-south-west direction across the centre of the district. Proceeding from west to east, the following deposits may be mentioned :—

	Analysis : Per cent.				
	Manganese.	Iron.	Silica.	Phosphorus.	Water.
1. West of the Wainganga river :—					
Thirori.—Five parallel ore bands exposed in places over a total length of 6 miles. Much of the ore high grade, consisting of a hard grey mixture of psilomelane and braunite.	52·29	7·77	3·86	0·11	0·38
Ramrama.—Outcrop $\frac{3}{8}$ mile in length. One or two bands of good quality ore exposed.	52·78	7·83	5·35	0·09	0·22
Katangjheri.—(*a*) Outcrop 500 yards in length. Hard grey ore interbanded with quartzite passing into soft lower grade ore.	53·96	5·97	6·02	0·04	0·23
(*b*) Outcrop nearly $\frac{1}{2}$ mile in length. Only workable portion consists of "speckled ore."	49·08	6·63	1·62	0·11	0·85
2. East of the Wainganga river :—					
Balaghat.—Length of ore band, $1\frac{1}{4}$ mile, maximum thickness about 45 feet. In part grey psilomelane, and in part light-grey crystalline hollandite.*	52·63	5·28	2·62	0·05	0·12
Ukua.—Length of ore band, 3 miles, maximum thickness about 19 feet. Occurs on same horizon as the Balaghat. Ores, psilomelane and braunite.	51·54	7·38	3·86	0·18	0·35

* A manganate of barium, manganese, and iron.

Bhandara District.—The ores of this district occur as lenticular bands, associated with gondite rocks, in a series of quartzites, schists, and gneisses forming an extension of the manganese-bearing zone of western Balaghat. The rocks occupy an area 20 miles in length with a maximum width of 18 miles in the north-west of the district. Three groups of deposits are known :—

	Analysis : Per cent.				
	Manganese.	Iron.	Silica.	Phosphorus.	Water.
Group 1.					
Kosumbah.—Three lenticles of ore on one line of strike, outcropping for $\frac{1}{8}$ mile.	50·62	10·10	3·95	0·138	0·40
Sitapathur.—Ore band traced for $1\frac{1}{8}$ mile. Width 12–20 feet. Ore a mixture of psilomelane and braunite.	51·70	8·14	6·19	0·10	0·17
Miragpur.—Six separate masses of ore consisting of a hard grey braunite-psilomelane mixture, interbanded with quartzite and braunite.	49·81	8·74	5·89	0·09	0·34
Group 2.					
Kurmura.—Outcrop $1\frac{1}{4}$ mile in length, 40 feet in width. Ore a mixture of brannite with psilomelane and pyrolusite with psilomelane.	51·11	5·58	4·09	0·22	0·34
Chikhla.—Outcrop about $2\frac{3}{4}$ miles in length, maximum width 80 feet. Ore a mixture of braunite and psilomelane.	50·69	7·95	8·16	0·114	—
Sitasaongi.—Main ore band about 1,200 yards in length, and 12–53 feet in width. Composed of interbanded gondite and quartz, etc., with patches of workable ore.	53·29	4·83	6·26	0·085	0·21
Group 3.					
Pachara.—Ore band a horizontal lenticular bed varying in thickness from a few inches to $5\frac{1}{2}$ feet. Composed of a psilomelane-braunite mixture.	52·09	3·86	2·61	0·166	1·15

Chhindwara District.—The deposits of this district occur in an area 17 miles in length from north to south, with an average width of about 7 miles. The ores form lenticular bands intercalated along the strike of a complex series of metamorphic rocks intruded by granites and pegmatites.

	Analysis : Per cent.				
	Manganese.	Iron.	Silica.	Phosphorus.	Arsenic.
Kachi Dhana.—Outcrop about ½ mile in length. Ore varies from mixtures of braunite and psilomelane to finely crystalline braunite with unaltered spessartite rock, etc.	51·87 to 56·82	2·82 to 5·30	1·10 to 16·27	0·004 to 0·135	
Sitapar.—Outcrop an elliptical hillock, 27 yards in length by 23 yards in breadth, and 20–25 feet in height. Ore-body 158 feet in length and 133 feet in thickness. The ore is unique, including six different manganese minerals.	54·77	6·96	7·42	0·089	0·032
Ghoti—Two parallel ore bands, about 750 and 440 yards in length respectively. Ore a mixture of psilomelane and braunite.	49·55	7·71	8·74	0·279	
Gowari Warhona.—Ore band, proved for 1,600 feet, has average thickness of about 6 feet. Ore consists of braunite, psilomelane and hollandite in varying proportions.	53·59	5·00	6·21	0·074	

Nagpur District.—The ores of this district occur in a belt forming a western continuation of the manganese-bearing rocks of Bhandara and Western Balaghat. The belt is 31 miles in length from east to west, and has a maximum breadth of 11 miles. The rocks are of the same character as those of the Chhindwara district and include acid and pyroxene gneisses, hornblende- and mica-schists, quartzites, and crystalline limestones, arranged in parallel discontinuous bands. The ore deposits are divided into two classes :—

(i.) Ores occurring as lenticular bands intercalated between the gneisses, schists, and quartzites, and associated with gondite or rhodonite rock, or with both.

(ii.) Ores in crystalline limestones, in the form of lenticles or bands of nodules.

These two classes are subdivided into geographical groups, as follows :—

	Analysis : Per cent.				
	Manganese.	Iron.	Silica.	Phosphorus.	Water.
CLASS I.					
GROUP 1.					
Kodegaon.—Two separate ore bodies : No. 1 a 2 : 1 mixture of braunite and psilomelane, the mass being 205 feet in length by 115 feet in width. No. 2 measures 300 feet in length by 20—80 feet in width. Average analysis, both deposits.	52·54	7·60	4·08	0·10	0·28
Gumgaon.—Ore band 1,200 feet in length by 300 feet in width, but good ore only 50 feet in width. It is a hard braunite-psilomelane mixture.	53·05	5·56	4·47	0·12	0·33
GROUP 2.					
Kandri.—Ore band forms a horse-shoe curve ½ mile in length rising into hills having a maximum height of 260 feet. Ore is braunite with some psilomelane.	54 to 57	3 to 5	8 to 10	0·08 to 0·12	—
Mansar.—Ore band outcrops for 1½ mile, rising to height of 350 feet above the surrounding plain. For about two-thirds of its length, on the crest of the hill, the band consists almost entirely of high-grade ore of uniform composition, with an average thickness of 45 feet. Ore consists of braunite with hard bands cemented by psilomelane.	54·46	4·82	8·36	0·07	—
GROUP 3.					
Parsioni.—Ore band about 2 miles in length, with average thickness of 50 feet.	—	—	—	—	—
Beldongri.—Ore-body nearly 300 feet in length and about 60 feet in width, but about one-half the thickness is rendered worthless by patches of manganese silicates. Ore varies from friable granular braunite to hard compact varieties.	53·70	5·53	4·94	0·06	1·02

	Average : Per cent.				
	Manganese.	Iron.	Silica.	Phosphorus.	Water.
Lohdongri.—Ore-body 380 yards in length, 200 yards in breadth, and rises to a height of 30–35 feet above the general surface level. The thickness of the deposit may amount to 60 feet, practically all composed of workable ore, either coarse crystalline braunite, or fine-grained psilomelane with patches of braunite.	47·12 to 50·64	7·34 to 10·62	6·40 to 7·45	0·054 to 0·098	— —
Kacharwahi. — Ore-body about 100 yards in length, 92 feet in width, and of considerable depth. Composed of layers of ore 5–10 feet in thickness, interbedded with hard quartzite and soft schistose rocks. Ore is a fine to coarse grained mixture of braunite and psilomelane.	52·81	6·55	7·57	0·069	0·28
Waregaon.—A deposit opened up in alluvium, the ore band being exposed for length of about 300 feet, the thickness being about 30 feet. Work abandoned owing to influx of water.	50·45	8·22	6·88	0·068	0·50
GROUP 4.					
Mandri. — Two roughly parallel ore bands, the northern about 270 yards in length and 6–14 feet in width, the southern about 590 yards by 24–40 feet.	53·23	5·27	6·04	0·106	0·73
Manegaon.—Two bands exposed : the main about 1½ mile in length, average width 50 feet ; the other 600 yards in length. Only a portion of these bands is merchantable ore.	49·15	10·26	5·31	0·09	0·35
Guguldoho. — Ore band 1½ mile in length, but only 350 yards contains workable ore.	46·24	16·34	2·90	0·183	0·54
CLASS II.					
Small masses, beds and bands of nodules in crystalline limestones, too poor to work *in situ*, though the residual accumulations on the surface are sometimes exploited profitably.					
Mandir Bir.—Residual nodular ore derived from a crystalline limestone by weathering. Band traced for over 6 miles.	50 to 52	2 to 4	5 to 9	0·05 to 0·12	—

Range of Analyses of Manganese Ores from the gonditic deposits of the Central Provinces.

(Rec. Geol. Surv. India, 1919, *50*, 292.)

[*Note.*—The averages of these analyses are given in brackets.]

District.	No. of Analyses.	Manganese.	Iron.	Silica.	Phosphorus.	Water.
Balaghat...	13	49·08 to 54·51 (51·88)	5·28 to 9·10 (7·40)	1·62 to 6·02 (3·74)	0·04 to 0·24 (0·11)	0·12 to 0·85 (0·37)
Bhandara ..	13	49·00 to 54·07 (51·94)	3·86 to 10·25 (7·27)	2·08 to 6·50 (4·59)	0·06 to 0·34 (0·14)	0·09 to 1·00 (0·44)
Chhindwara	9	48·95 to 54·97 (52·72)	5·00 to 11·77 (7·08)	4·98 to 10·63 (7·16)	0·06 to 0·28 (0·11)	0·00 to 1·27 (0·38)
Nagpur ...	30	42·28 to 56·52 (51·53)	2·09 to 16·34 (6·24)	2·90 to 18·48 (7·25)	0·04 to 0·65 (0·215)	0·11 to 1·32 (0·49)

The above samples were taken at or close to the surface, and deeper working is revealing a tendency towards a progressive increase of phosphorus contents with depth.

Jubbulpore District.—The ores consist of manganiferous weathering products, to which Fermor has given the name "lateritoid," and may contain hæmatite, psilomelane or impure pyrolusite. The ores won are mainly second-grade manganese ores and third-grade ferruginous manganese-ores, and are of little value economically. A few tons have been mined in recent years, possibly for special purposes.

	Analysis : Per cent.			
	Manganese.	Iron.	Silica.	Phosphorus.
Mansakra.—Deposit consists of brecciated quartzite cemented by pyrolusite and limonite with veins of pyrolusite and psilomelane. Ore-body 240 feet in length, 120 feet in breadth and 10 feet in thickness.				
Gosalpur.—Deposit consists of pyrolusite nodules, with subordinate amounts of psilomelane and iron ore, forming a layer of varying thickness in the soil.	54·66	3·17	2·74	0·12

The quality of the ores available for extraction near Sihora and Gosalpur is shown by the following recent summary of analyses(1) :—

[*Note.*—The averages of these analyses are given in brackets.]

——	No. of Analyses.	Manganese.	Iron.	Silica.	Phosphorus.	Water.
Manganese ore.	3	34·53 to 56·80 (45·56)	1·60 to 10·30 (4·79)	1·40 to 4·79 (2·68)	0·03 to 0·46 (0·215)	03·9 to 0·90 (0·56)
Manganiferous iron-ore.	7	6·20 to 25·60 (20·26)	19·17 to 47·10 (28·78)	4·40 to 23·40 (12·99)	0·02 to 0·85 (0·25)	0·12 to 0·65 —

[1] Rec. Geol. Surv. India, 1919, *50*, 293.

Bombay Presidency.

Panch Mahals.

——	Analysis : Per cent.				
	Manganese.	Iron.	Silica.	Phosphorus.	Water.
Sivarajpur.—Ore-bodies of considerable size occur along the crest of a ridge for about 3 miles. Ores consist of psilomelane with some braunite and pyrolusite, and have been partly formed by replacement of limonitic quartzites of the Dharwar series.	30·20 to 49·35	3·05 to 6·25	2·80 to 40·65	0·16 to 0·25	0·30 to 0·40

Central India.

Jhabua.

——	Analysis : Per cent.			
	Manganese.	Iron.	Silica.	Phosphorus.
Kajlidongri.— The ores outcrop for length of 1,000 yards and form a bed 20 feet in thickness associated with phyllites, gondite and quartzites. Ores consist of braunite and mixtures of braunite and psilomelane :—				
Northern portion	46 to 52	8 to 9	7 to 11	0·15 to 0·30
Southern portion	46 to 48	8 to 9	6 to 9	0·08 0·25

Mysore State.

The manganese ores of Mysore are all of a superficial character. They form masses, often of considerable size, in the weathered portion of the rock, and occur also as concretionary nodules and nests in the underlying lithomarges, phyllites and quartzites, either as psilomelane or as pyrolusite. The depth of the deposits is shallow and the grade of the ores comparatively low. They contain high percentages of iron, but are low in silica and phosphorus. The deposits occur on the outcrops of the Dharwar rocks of the plateau of Mysore.

Chitaldroog District.—At Sudarhalli, in this district, a replacement deposit, varying in thickness from 2 to 20 feet, caps the surface of a hill; it contains psilomelane, and about 10,000 tons of ore may be available. Many similar deposits are known to occur in the district.

Kadur District.—In this district large deposits of nodular psilomelane occur in a clay matrix at the base of Kannikalmatti Hill.

Shimoga District.—The principal deposits of this district are in the Shikarpur, Kumsi, Channagiri, Tuthalli and Shimoga taluks. The ores occur as superficial masses, resting on the outcrops of the Dharwar rocks, usually forming horizontal cappings on the tops of the hills. The ores are usually of second or third grade, containing on an average about 47 per cent. of manganese.

Tumkur District.—The deposits of this district are all situated within 12 miles of Chiknayakanhalli. The ores are of poor quality, probably averaging not more than from 42 to 45 per cent. of manganese.

Bihar and Orissa (*Gangpur District*).

	Analysis: Per cent.			
	Manganese.	Iron.	Silica.	Phosphorus.
Gariajhon.—Outcrops of manganese ore occur in a band of gondite rocks extending for about 3½ miles. The most important ore-body forms the crest of Gariajhon hill, and is about 720 feet in length and 10–20 feet in thickness.	45·48 to 58·64	1·70 to 16·33	0·65 to 11·20	0·08 to 0·15

Madras Presidency.

Bellary District (*Sandur Hills*).—The Sandur Hills are composed of bands of schists, phyllites, and ferruginous quartzites with interbedded igneous rocks. The whole series is disposed in a great synclinal trough, and the ores are almost entirely confined to the crest and western slopes of the western limb of the syncline, being especially developed on the outcrops of the phyllites, which have been impregnated and replaced by ore. The principal constituents of the ores are psilomelane and wad. Secondary pyrolusite and manganite occur in cavities. Braunite is found in smaller amount. The total reserves of the Sandur Hills have been estimated at about 10 million tons, including ferruginous manganese-ores. As a rule, the ores are not of high grade, although the proportions of silica and phosphorus are low; they usually contain a high percentage of iron oxide. A typical analysis shows 45 per cent. of manganese, 12 of iron, about 1 of silica, and 0·01 of phosphorus.

Vizagapatam District.—The composition of the ores associated with the kodurite series of this district varies in different localities, the principal ores consisting of psilomelane with subordinate amounts of pyrolusite and braunite. The ores vary from ferruginous manganese-ores, containing from 13 to 19 per cent. of iron, to manganese ores with 43 to 50 per cent. of manganese. The proportion of phosphorus is often rather high, but that of silica is comparatively low.

	Analysis : Per cent.			
	Manganese.	Iron.	Silica.	Phosphorus
Kodur.—Here a manganiferous belt about 3 miles in length is worked at intervals.	47·11	9.70	3·15	0·191
Garbham.—Ore-body has proved length of 2,200 feet, and possibly extends for a further 2,000 feet. It is 167 feet in thickness at the middle, and has been proved to a depth of at least 100 feet. The ores consist chiefly of a dull grey psilomelane with patches of other ores, and are generally of third grade and often highly ferruginous—				
Manganese ore	45·39	9·99	4·43	0·45
Ferruginous manganese-ore ...	35·43	19·32	6·90	0·423

Deposits of manganese ores have been found in numerous other localities.

Production and Exports of Manganese Ore, British India.

For the quinquennial period 1909-10 to 1913-14 the total recorded export of Indian manganese ore amounted to 3,035,530 tons (not including exports *via* Mormugao, Portuguese India), the yearly average being 607,106 tons. These exports were distributed as follows :—

Country	Percentage.
United Kingdom	31·8
Belgium	24·7
United States	21·8
France	16·0
Holland	3·1
Germany	1·1
Japan	0·6
Italy	0·5
Austria-Hungary	0·4
Total ...	100·0

During the war the Belgian market for Indian manganese ores was lost, while exports to the United States were greatly diminished.

The following tables show (1) the quantities of manganese ore produced annually in British India during the war (calendar years), with the shares of the different provinces, and (2) the quantity and value of the manganese ore exports during the period (fiscal years), showing the distribution of the shipments.

Production of Manganese Ore in British India.

(Statistical Abstracts relating to India, and Rec. Geol. Surv. India.)

Year.	Quantity (long tons).						
	* Bihar and Orissa.	† Bombay.	‡ Central India.	§ Central Provinces.	‖ Madras.	¶ Mysore.	Totals for whole of British India.
1913 ...	11,215	40,914	6,814	649,307	96,296	10,501	815,047
1914 ...	6,070	27,223	6,642	564,890	60,018	18,055	682,898
1915 ...	507	26,915	366	399,215	288	23,125	450,416
1916 ...	2,834	55,876	—	558,828	2,755	24,911	645,204
1917 ...	11,906	27,107	—	517,841	1,682	32,277	590,813
1918 ...	16,345	38,095	—	438,628	2,230	22,655	517,953
1919 ...	21,533	44,533	—	441,475	2,778	24,676	534,995

* Gangpur and Singhbhum.
† Panch Mahals and Chota Udepur.
‡ Jhabua.
§ Balaghat, Bhandara, Chhindwara, Nagpur, and Jubbulpore.
‖ Sandur and Vizagapatam
¶ Chiefly Shimoga.

The values per ton (*f.o.b.* at Indian ports) of ore produced by the respective provinces in 1918 were :—Bihar and Orissa, £2·6; Bombay, £2·6; Central Provinces, £2·9; Madras, £1·5; Mysore, £1·9.

Exports of Manganese Ore from British India.

(*Fiscal years ended March 31st.*)

Values *f.o.b.* at Indian Ports.

(Annual Statement, Sea-Borne Trade of British India.)

To	Quantity (long tons).					
	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	258,776	227,281	380,967	463,850	313,468	295,230
Egypt (*)	—	—	—	200	—	—
Total to British Empire.	258,776	227,281	380,967	464,050	313,468	295,230
Austria-Hungary ...	10,310	4,030	—	—	—	—
Belgium	187,821	66,043	—	—	—	6,560
France	103,847	46,326	20,000	61,940	48,055	57,400
Germany	18,950	14,250	—	—	—	—
Holland	8,200	—	—	—	—	—
Italy	7,800	—	20,850	28,400	10,200	1,575
Japan	16,018	9,157	3,346	17,480	17,557	14,996
China (†)	—	—	—	1	—	—
United States ...	106,327	73,503	47,400	65,062	44,051	9,600
Total to Foreign Countries.	459,273	213,309	91,596	172,883	119,863	90,131
TOTAL ...	718,049	440,590	472,563	636,933	433,331‡	385,361
Share of Bengal ...	74,575	61,054	77,648	233,337	178,323‡	204,935
„ *Bombay* ...	606,724	365,286	392,915	394,146	247,608	180,376
„ *Madras* ...	36,750	14,250	2,000	9,450	7,400	50
TOTAL (tons) ...	718,049	440,590	472,563	636,933	433,331‡	385,361
	£	£	£	£	£	£
TOTAL (value) ...	808,763	502,019	553,906	836,171	571,121‡	501,533
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Average value per ton	22 6·3	22 9·5	23 5·3	26 3·1	26 4·3	26 0·4

* Included in "Foreign Countries" prior to 1915–16.
† Exclusive of Hongkong and Macao.
‡ Includes 1,501 tons of ferro-manganese, valued at £23,347.

By calendar years, the quantities of manganese ore exported were as follows :—1913, 772,336 tons; 1914, 537,960 tons; 1915, 418,733 tons; 1916, 580,328 tons; 1917, 514,424 tons; 1918, 350,826 tons; 1919, 370,459 tons; and 1920, 711,424 tons.

Indian Ferro-Manganese.

Ferro-manganese appears in the Indian export returns for the first time in the fiscal year 1916-17. The alloy is made by the Tata Iron and Steel Co., Ltd., at Jamshedpur (late Sakchi) in

Bihar and Orissa, and the Bengal Iron and Steel Co., Ltd., at Kulti, Bengal. The quantities and values of ferro-manganese exported are as follows :—

(Handbook of Commercial Information for India, by the Collector of Customs, Calcutta. Annual Statement of the Sea-Borne Trade of British India, Vol I.)

Fiscal Year.*	1916–17.	1917–18.	1918–19.
Quantity, tons	2,608	2,101	10,878
Value, total	£60,424	£38,346	£272,045
„ per ton	463*s.* 4·5*d.*	365*s.* 0·3*d.*	500*s.* 2·1*d.*

The exports of ferro-manganese in 1918-19 were distributed as follows, the port of shipment being Calcutta :—

(Annual Statement of Sea-Borne Trade of British India, 1918-19, Vol. I.)

To	Quantity (long tons).	Value† (£).
British Possessions :		
United Kingdom	103	2,572
Natal	50	1,250
Canada	1,997	49,933
Total to British Possessions	2,150	53,755
Foreign Countries :		
France	999	24,993
Italy	4,453	111,313
United States	900	22,500
Japan	2,376	59,484
Total to Foreign Countries	8,728	218,290
TOTAL	10,878	272,045

Labour.

Some 20,000 workers are employed annually in the manganese quarries. In Vizagapatam and Mysore, native labour is easily obtainable ; but in the Central Provinces, Central India and the Sandur Hills, workers have frequently to be imported. The rates of wages paid to labourers in the Central Provinces vary from 3 to 8 annas per day. The mine owners usually work through contractors, paying them at a given rate per 1,000 cubic feet of stacked and clean ore, and for dead-work per 1,000 cubic feet of cavity made by the removal of soft " deads," or, in the case of hard " deads," per 1,000 cubic feet of stacked waste.

* Ended March 31.

† Rupees converted at R.15 = £1. The average rate of exchange during 1918–19 was 1*s.* 5·544*d.* per rupee.

Royalty.

As a general rule, mines in British India are subject to a royalty of 2½ per cent. on the sale value of ore at the pit's mouth; but, as this is inconvenient to users in the case of manganese ores, the rate has been fixed as follows, except in the case of Madras: ½ anna per ton of ore when the price per unit of first-grade ore is 8*d.*, and ½ anna for each additional penny in the unit price up to 11*d.* When the price per unit is 12*d.* the royalty is 3 annas per ton of ore, an addition of 1 anna being made for each additional penny in the unit price up to 14*d.*, the scale thereafter up to 18*d.* being enhanced by a further 2 annas for every extra penny in the unit price. The royalties in the Indian States are generally considerably higher than this.

Average Cost of Indian Manganese Ore Delivered c.i.f. at English and Continental Ports.

The average cost per ton of Indian manganese ore in general delivered *c.i.f.* at English ports during the period under review can be calculated from the table (p. 28) showing the quantities and values of manganese ore imported into the United Kingdom. The following table shows the average cost per long ton delivered *c.i.f.* at English and Continental Ports of manganese ore from the different producing areas in India, immediately prior to the war (rupees converted at rate of Rs. 15 = £1 then ruling):—

(Rec. Geol. Surv. India, 1915, *46*, 150.)

Producing Area.	Port from which exported.			
	Bombay.	Calcutta.	Viza-gapatam.	Mormugão.
	s. d.	*s. d.*	*s. d.*	*s. d.*
Central Provinces	35 10	42 2	—	—
Gangpur, Bihar and Orissa ...	—	29 9	—	—
Jhabua, Central India ...	29 7	—	—	—
Panch Mahals, Bombay ...	35 4	—	—	—
Vizagapatam, Madras ...	—	—	31 3	—
Sandur, Madras	—	—	—	31 3
Mysore	—	—	—	39 4

Prices of Indian Manganese Ores during the War Period.

The normal pre-war market prices of Indian manganese ores in London were approximately as follows:—

	Pence per unit.
1st grade ores (50 per cent. manganese and upwards)	10
2nd grade ores (48-50 per cent.)	9-9¾
3rd grade ores (48-50 per cent.)	8-9

In 1914 the average price per unit was 9*d.* as against 11*d.* in 1913. When war broke out, the hostile European markets and those of Belgium and Holland were closed, and direct export to the United States was prohibited; and, although there was a rise in the price in the last quarter of the year, only isolated cargoes were sold, the rise being due solely to enhanced freight rates, consequent on the shortage of shipping tonnage.

During the first half of 1915, the Indian manganese industry was greatly depressed. In August of that year a strong demand for ore arose in the United Kingdom, France, and the United States; but, owing to shortage of shipping, especially towards the end of the year, this could not be fully met. In consequence, prices advanced, 17½*d.* per unit being reached, but this followed the abnormal increase in ocean freights, insurance, and other charges incidental to shipping, the result to the mine-owner being no better than in normal times.

Throughout 1916, there was a strong demand for manganese ore for munition purposes in all the allied countries, and the Indian mines were vigorously worked. The shortage of shipping was to some extent relieved by special arrangements made by the Government. Prices continued to advance, and the average rate per unit for the year was 29¼*d.* Against this there had to be set a further increase in freights and other charges, but the results were more favourable to the mine-owner than those of 1915.

In 1917, the demand for ore continued strong from all the allied countries. The shortage of shipping also continued, but, as in 1916, was relieved by special arrangements. The rise in prices persisted, the average rate per unit for the year being 37½*d.* The further rise in freights, insurance and other charges resulted, however, in the mine-owner being in about the same position as in 1916.

In 1918, a fair demand continued until the signing of the Armistice, when there was an appreciable abatement. Prices rose to 44*d.* per unit, but this record figure was due entirely to the further increase in ocean freights, which reached 126½*s.* per ton, with the consequence that the net results to the mine-owner were no better than in the two preceding years.

The demand for Indian manganese ore during 1919 was smaller than in the previous year, and prices averaged only about 28½*d.* per unit. The average ocean freight, however, fell to about 78*s.* 6*d.* per ton, and this decrease counterbalanced the decline in prices, the net result to the exporter being about the same as in 1918.

Australia.

The production of manganese ore in Australia is very small, owing to the limited domestic demand for such material; but it is believed that, with the development of iron and steel manufacture in the Commonwealth, production will be stimulated, and

that sufficient manganese ore could be raised to supply the full requirements of that industry.

New South Wales.—Ores of manganese have been found in considerable quantities in many parts of this State, but generally in localities somewhat remote from the coast and lacking proper transport facilities. The deposits occur in Palæozoic and Mesozoic strata, in Pleistocene clays, and associated with intrusive hornblendic rocks and serpentines. The commonest ores are pyrolusite and psilomelane, but manganite, dialogite, rhodonite, and braunite are also found. Manganiferous iron-ores occur in the Mudgee district. The total recorded output of manganese ore in New South Wales up to the end of 1912 was only 577 tons, valued at £1,662, these figures representing exports. The production since then is shown in the general table for the Commonwealth.

Victoria.—Manganese oxide occurs in the Snowy River porphyries at Nowa Nowa and in a lode near the Buchan-Snowy River junction, East Gippsland; but the very small quantity of manganese ore hitherto produced in this State has come from deposits in a vein stockwork at Heathcote, Bendigo District. There appears to have been no output since the end of 1916, up to which date the total production of Victoria was only 247 tons, value £919.

Queensland.—The manganese ore occurrences of this State have been described by B. Dunstan.* The most important are in the Gladstone and Rockhampton districts, the mine at Mount Miller near the former town being by far the largest producer of manganese ore in the State. The occurrences are principally in ferruginous slates, schists, quartzites, and other altered sedimentary rocks.

In the Gladstone district the deposits are sometimes lenticular, but in general irregular in shape and occurrence, the manganese ore area being roughly 15 miles in length with a maximum width of 12 miles. The workings of the Mount Miller mine are situated in a hill rising about 400 feet above the Calliope River, the width of clean ore varying from 3 to 21 feet. The ore is chiefly psilomelane, but contains also pyrolusite, the impurities being mainly silica and country rock. During the period 1895-1913, this mine produced 14,172 tons of manganese ore, containing on an average 75 per cent. of manganese dioxide (equivalent to about 47 per cent. of manganese). In July, 1914, the ore reserves were estimated by L. C. Ball† at 35,350 tons, containing from 18 to 51 per cent. of manganese. Of this, 26,925 tons were estimated to contain from 40 to 51 per cent. of manganese. The phosphorus content is not, so far as known, high enough to affect prejudicially the value of the Mount Miller ore; but silica is present in large amounts in some of it, and,

* Queensland Mineral Deposits; Queensland Govt. Min. Journ., Brisbane, 1917, *18*, 286.

† Mount Miller Manganese Mine; Queensland Govt. Min. Journ., Brisbane, 1915, *16*, 12.

according to Ball, is likely to increase as depth is attained and psilomelane gives way to braunite and rhodonite. Analyses of the highest-grade ore showed 5 per cent. of silica, and the percentage in the ore of the deeper levels is so high that selective mining, and possibly surface treatment in addition, would be required to give a product acceptable by smelters. The output has been used at the Mount Morgan gold mine in the chlorination process. Occasional small shipments of manganese ore have also been made since 1895 from deposits at Auckland Hill in the same district, the ore averaging 65 per cent. of manganese dioxide.

Manganese is common in the rocks of the Gympie Goldfield, in Middle Gympie formation, and there is said to be a large area of undeveloped manganese-bearing country in this region, the deposits occurring as irregular masses in slate, quartzite, and jasper.*

Manganese deposits have also been worked on a small scale in the Gore district, and occurrences in the Cairns district have recently been described by H. I. Jensen,† who estimates the deposits of that region as being both large and of high average grade, and therefore likely to prove very valuable.

Western Australia.‡—Deposits of manganese ore occur in many localities of this State, but there has been practically no production of such ore up to the present time. In 1908-9, 2 tons, valued at £4, and in 1914-15, 3 cwt., produced in the South-West Division, were exported, the precise locality from which these small quantities were obtained not being reported. The most important manganiferous iron-ore deposits so far discovered in Western Australia occur on the South Coast. Large deposits of such ore exist in the Eyre Range, between Phillips and Hamersley Rivers, near Culham Inlet, but no mining has been done on these. About 5 tons of manganese ore are stated to have been exported from the south coast, but nothing is known as to the nature and geological relations of the deposit worked. A manganese deposit of the true fissure lode type has been opened out to a slight extent on the Hamersley River, this occurring in association with the sedimentary quartzites of the Mount Barren Ranges. The lode trends generally east and west across the Hamersley Gorge. An analysis showed the following percentage composition :—manganese, 32·58; ferric oxide, 21·31; water, 6·44; insoluble, 21·12; and undetermined, 1·30.

Cobaltiferous manganese ores occur in the Barren Ranges, on Gardner River, samples yielding : manganese, 34·67 to 41·86 per cent.; cobalt, 0·39 to 0·67; nickel, trace to 0·25; silica, 15·32 to 17·94; with 1·8 to 2·7 dwt. of silver per ton.

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* Ferro-Alloys and Alloy Steels : Bull. No. 9, Advisory Council of Science and Industry, Commonwealth of Australia, Melbourne, 1918.

† The Manganese Ores of the Cairns District : Queensland Govt. Min. Journ., Brisbane, 1919, *20*, 53.

‡ A. G. Maitland ; The Manganese Deposits of Western Australia : Mining Handbook Geol. Surv. Memoir No. 1, Chapter II, Economic Geology, Perth, W.A., 1919.

A deposit of high-grade manganese ore (pyrolusite and psilomelane) occurs at Desmond, in the Phillips River Goldfield, on the old Mt. Chester Lease M.L. 250. The lode can be followed along the surface for about 800 feet, the deposit, which has an underlie of 70° to 75° to the south-west, lying in a belt of schists forming the Ravensthorpe series. A clean body of ore, 20 feet in width, was exposed by a trench, and an adit driven 90 feet below the outcrop cut the lode at 300 feet in, the ore-body measuring 20 feet across and containing two veins of manganese ore, the larger being 9 feet in width. Two samples yielded the following percentages on assay: (1) massive dense pyrolusite: manganese, 48·20 per cent.; iron, 9·80; silica, 2·20; (2) soft powdery pyrolusite: manganese, 21·41; iron, 27·35; silica, 1·76. A complete analysis of another sample from this locality gave: manganese, 43·99 per cent.; ferric oxide, 7·77; silica, 10·84; phosphorus pentoxide, 0·18; cobalt oxide, 0·45: nickel oxide, 0·06; alumina, 3·91.

Many of the Western Australian laterites contain appreciable quantities of manganese, sometimes as more or less spherical concretions; but it is regarded as unlikely that they will ever constitute a source of exploitable manganese ores.

It has recently been reported* that a company owning deposits of manganese ore at Horseshoe Range, Peak Hill Goldfield, is seeking authority to construct a railway, 87 miles in length, from the locality to Meekatharra, which is 369 miles by rail from the port of Geraldton. The State Mining Engineer, in a recent report on the Horseshoe Range, stated that a safe estimate of the ore available would be 1¼ million tons from open excavations on the superficial crust, with probably larger quantities below. In addition there are said to be very large quantities of ferruginous manganese-ore, which would be valuable for iron and steel manufacture. Analyses of bulk samples at the laboratory of the Geological Survey showed percentages ranging as follows:—

	Per cent.		Per cent.
Manganese	24·16	to	52·14
(Manganese dioxide	59·15	,,	78·34)
(Manganous oxide	2·91	,,	5·71)
Iron	3·48	,,	34·49
(Ferric oxide	4·97	,,	49·27)
Silica	0·36	,,	2·82
Water	0·43	,,	0·88

It will be noted that the percentage of silica is satisfactorily low. The percentage of phosphorus is not stated.

The State Mining Engineer calculates that the total cost of production and delivery to the European market would be £6 5*s.* per ton, the expenses being apportioned as follows: mining,

* Chem. Eng. and Min. Rev., Melbourne, 1920, *13*, 97.

3*s.*; road transport, £2; rail transport, 7*s.*; port expenses, 10*s.*; freight, £2 15*s.*; insurance, landing expenses, agency, etc., 10*s.* He estimates that ore from this locality containing 46 per cent. of manganese would yield a substantial profit. The manufacture of ferro-manganese from the lower-grade ferruginous ore for export is suggested.

South Australia.—Production of manganese ore in this State began in 1882 and was continuous until 1895, the output to the end of that year amounting to 13,112 tons, valued at £45,911. This ore appears to have been mainly produced at the South Australian Mine, Boolcunda Creek, near Willochra, where there are four parallel lodes, one averaging 9 feet in width and the others from 2 to 5 feet, composed of pyrolusite, manganite and psilomelane. For 1896-1900 no production is recorded; for 1901-1903 the output was only 160 tons, valued at £411; and there was no further production of the ore until after the outbreak of the war. The output since then is given in the general table for the Commonwealth.

Manganese deposits are being worked by the Australian Manganese Company and others on the western side of Pernatty Lagoon, the main group of claims being about 4 miles N.E. from Woocalla, 71 miles from Port Augusta on the railway to Kalgoorlie. These deposits have been described by the Government Geologist.* The first claims worked for manganese in this locality appear to have been taken up in 1914, when 50 tons of 50 per cent. ore were raised; but it was not until 1916 that the deposits attracted much attention. A reddish quartzite or sandstone forms the bed rock of the district. At the manganese claims, an extensive formation of impure manganiferous and ferruginous dolomite rests on the quartzite, the ore deposits occurring as segregations in the residual clay resulting from the decomposition of the dolomite. In the case of the larger deposits, only occasional outcrops of manganese ore and dolomite, and, to some extent, the colour of the overlying soil, afford any guide to their limit. Owing to the nature of the deposits and the want of sufficient prospecting, it is impossible to estimate the total tonnage of ore; but it is regarded as certain that a very large amount is obtainable from the various leases and claims of the Australian Manganese Company, and that further prospecting will add considerably to the known occurrences. A large tonnage of ore suitable for steel manufacture can be obtained by sorting the masses of ore from the clay, with but little cleaning; while also a considerable tonnage of chemical grade ore can be obtained by selection. Mining is cheap, the overburden being generally not more than 2 feet in thickness, and little or no explosives being required.

The total quantity of ore shipped by the Australian Manganese Company from their workings at Pernatty Lagoon from January, 1917, to April, 1919, was 841 tons, of which 735 tons were sold.

* Review of Mining Operations in South Australia, No. 25 (July-December 1916), and No. 31 (July-December, 1919): Dept. of Mines, Adelaide.

Of this total, two lots, analysed in London, gave the following results after drying at 212°F. :—

...	Lot 1.—164 tons. Per cent.	Lot 2.—152 tons. Per cent.
Manganese dioxide ...	86·64	85·83
Manganous oxide	1·49	1·61
Ferric oxide	4·29	4·89
Silica	1·80	1·60
Alumina	1·18	1·48
Lime	0·40	0·30
Magnesia	0·18	0·19
Sulphuric anhydride ...	0·26	0·242
Phosphoric acid	0·078	0·089
Oxide of copper	0·02	trace
Carbon dioxide	trace	trace
Combined water	3·37	3·62
	99·708	99·851
Metallic manganese ...	55·93	55·51
Metallic iron	3·00	3·42
Sulphur	0·104	0·097
Phosphorus	0·034	0·039

An analysis of a shipment of 102 tons, made in New York, is stated by the Company to have shown 15·62 per cent. available oxygen (equivalent to 84·87 per cent. of manganese dioxide), and 3·44 per cent. of iron.

Production of Manganese Ore in the Australian Commonwealth.

Year.	New South Wales.		Victoria.		Queensland.		Western Australia.		South Australia.		Total.	
	Quantity (long tons).	Value (£).	Quantity (long tons).	Value (£).	Quantity (long tons).	Value (£).	Quantity (long tons).	Value (£).	Quantity (long tons).	Value (£).	Quantity (long tons).	Value (£).
1913	—	—	—	—	27	163	—	—	—	—	27	163
1914	—	—	20	70	6	27	—	—	—	—	26	97
1915	713	535	97	337	200	820	—	3	250	563	1,260	2,258
1916	1,924*	1,443*	85	300	643	2,793	—	—	544	2,700	3,196	7,236
1917	3,721*	2,791*	—	—	21	105	—	—	264	1,597	4,006	4,493
1918	6,512*	6,228*	—	—	1,299	4,151	—	—	1,080	17,876	8,891	28,255
1919	4,651	13,953	—	—	20	—	—	—	298	1,490	4,969	—

* Exports only.

New Zealand.

Manganese minerals occur in many parts of New Zealand, but the production of manganese ore in the Dominion has never been large, the total quantity exported from 1878 (when shipments began) to 1911 (when exportation entirely ceased) being, according to the Annual Mines Reports, 19,364 tons, valued at £61,905. It is not expected that exportation of manganese ore

could be profitably undertaken in the future, although there are a number of deposits that will be valuable when steel-making, glass-manufacture, and other industries requiring manganese have been established in the Dominion. A list of the localities in which manganiferous minerals occur has been given by P. G. Morgan,* the most common occurrences being manganite and psilomelane.

FOREIGN COUNTRIES.

Austria, Hungary, and Bosnia-Herzegovina.

The average annual output of these countries for the period 1910-1912 was approximately as follows:—Austria-Hungary, 21,000 long tons; Bosnia-Herzegovina, 5,100 tons. For the years 1909-1913, the separate production of Austria averaged 15,465 tons annually, and that of Hungary, 13,737 tons.† The outputs during the war period, so far as statistics are at present available, are shown in the table giving the world's production.

Not only has the production been small, but the ore is generally of low grade, and the steel industry has normally obtained practically all of its requirements of the material from Russia. The principal producing districts are situated in Carniola and the Bukowina. According to H. K. Scott,‡ rhodonite is found at Vigunsica, Carniola, as irregular bands in the Triassic strata; at Platten, in Bohemia, manganese ore occurs as films and stockworks in granite and mica-schists; at Krogle (near Donina), in Istria, the mineral is reported to contain 40 per cent. of manganese; at Kaskogerl, in Styria, rhodochrosite is found in Silurian limestone; at Felso-Visso, in Hungary, the same mineral occurs as beds; at Cevljanovio and Derazevic, near Serajevo, in Bosnia, the ore (pyrolusite and psilomelane) occurs in the Triassic strata and contains about 46 per cent. of manganese.

The manganese ore-bodies in the Bukowina§ (investigated by Scott in 1913) are situated on the slopes of the Carpathian Mountains in the Dorna Vatra district, the principal deposit, that of Arschitza, occurring near the village of Jacobeni. The exploratory work on the different outcrops of manganese ore was originally undertaken about the middle of the last century to discover iron ore suitable for use in blast and puddling furnaces, but the phosphorus and manganese in the Jacobeni limonite prevented its successful utilization. The ores now mined in the district occur as lenticular bodies, composed principally of rhodochrosite with some manganese as silicate, enclosed in mica schists, the carbonate being altered into manganese and iron oxides for a considerable depth below the surface. The average analysis of dried samples of ore from the three principal lenses developed at Arschitza, taken from the outcrop to the first level,

* The N. Z. Journ. of Science and Technology, Wellington, 1919, *2*, 113.

† The Mineral Industry, New York, 1916.

‡ Manganese Ores of the Bukowina; Journ. Iron and Steel Inst., London, 1916, *94*, 288.

§ By the Treaty signed at Trianon on 4th June, 1920, the Bukowina became part of the Kingdom of Rumania.

a depth of about 300 feet, showed the following percentage composition :—manganese, 33·06; iron, 14·50; silica, 17·36; phosphorus, 0·45. The average of the different official analyses of the mineral produced at the mine showed in the dry ore 30·30 per cent. of manganese and 0·34 per cent. of phosphorus. Samples taken by Scott of the washed-ore output of the dressing plant showed average percentages in the dried material as follows :—

	Washed Ore			Manganese Waste.	Manganese Mud.
	1st grade.	2nd grade.	Average.		
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Manganese ...	44·80	41·90	42·90	27·90	28·20
Iron	11·70	12·24	12·06	17·04	12·12
Silica	5·05	8·05	7·20	20·30	29·10
Phosphorus ...	0·365	0·430	0·41	0·534	0·390

The 1st grade product amounted to 12·8 per cent. of the output of the plant, the 2nd grade to 22·2 per cent., the manganese waste to 37·5 per cent., and the manganese mud to 19·2 per cent., while waste to river amounted to 8·3 per cent. The washed ore and manganese waste were sold to makers of ferro-manganese for the Austrian market, the former on a 46 per cent. and the latter on a 28 per cent. manganese basis, with a phosphorus penalty in both cases. The manganese mud was purchased by the Austrian Mining and Ironworks Company on a 28 per cent. manganese basis with a phosphorus penalty, and worked up in a rotary furnace with burnt pyrites and hot-blast stove flue dust. Selected crude ore was sold for use in the manufacture of basic pig-iron, the basis of sale being 37 per cent. manganese with a phosphorus penalty. Selected peroxide ore was sold to glass and chemical manufacturers, to the former on a 65 per cent. and to the latter on a 70 to 75 per cent. manganese peroxide basis. Schemes were under consideration in 1913 for more extensive mine development and the erection of a new dressing plant to handle 50,000 tons of ore per annum. Some 200,000 tons of ore had already been mined, and calculations showed that over 150,000 tons still remained unextracted in the lenses above No. 1 Level, while further quantities of both oxide and carbonate ore were expected to be proved at lower levels.

Imports and Exports of Manganese Ore into and from Austria-Hungary.

(*Stahl u. Eisen*, 1919, *33*, 951.)

Year.	Imports (long tons).	Exports (long tons).
1913	66,197	541
1914	54,645	233
1915	201	165
1916	1,035	516
1917	150	3,920

Belgium.

Small deposits of impure, low-grade manganiferous ore, suitable for the making of spiegeleisen, occur in the valley of the Lienne, province of Liége. Production began to assume fairly considerable size in 1887, when a branch railway to the district was completed. In 1888, an output of 27,340 tons was obtained but only about 14,200 tons were produced in 1902, and for the next few years there was practically no output. The production rose in 1908 to over 7,000 tons, but fell to 6,170 tons in 1909, after which year no mining appears to have been done until the Germans began to work the deposits in 1915. The Belgian manganiferous ore deposits, which are of two different types, sedimentary beds and alteration products in pockets, occur in the communes of Bihain, Malempré, Arbrefontaine (province of Luxembourg) and Lierneux (province of Liége). Analyses of samples taken by a German engineer in 1915 showed the following percentage composition* :—Manganese, 24·14 to 29·49; iron, 7·10 to 16·93; silica, 21·55 (average); phosphorus, 0·44 (average).

According to L. Eyben, director of the Société Maritime et Commerciale d'Anvers,† the annual consumption of manganese ore in Belgium is normally 115,000 to 120,000 tons, while the quantity of ferro-manganese imported annually is 10,000 to 15,000 tons, that of spiegeleisen being about the same. Belgium does not produce these alloys. In addition to the manganese ore consumed in the country, a large tonnage is received from abroad for consumers in Germany, Luxembourg (Grand Duchy) and other European countries.

Next to the United Kingdom, Belgium has normally been the largest buyer of Indian manganese ore, the proportion of the Indian exports received from April 1st, 1912, to March 31st, 1914, being 25·16 per cent., and for the financial year 1914-1915 (in which the war started), 15 per cent. Russian exports of manganese ore to Belgium in 1912 and 1913 represented 19·15 per cent., and in 1914, 22·75 per cent., of the total exports from the Tchiaturi field. As a purchaser of Brazilian manganese ore, Belgium ranked third in order of importance (taking in 1913, 6·42 per cent. and in 1914, 5 per cent. of the Brazilian exports), the United States being the largest buyer and the United Kingdom the second largest

Before the war, the Industrial and Commercial Company of Antwerp was one of the chief operating companies in the Tchiaturi district, owning a plant capable of producing 100,000 tons of 53 to 54 per cent. washed manganese ore per annum.

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* *Annales des Mines de Belgique*, Brussels, 1920, *21*, 36.
† *Ibid.*, 14.

Production of Manganese Ore in Belgium.

(*Statistique des Industries Extractives et Métallurgiques.*)

Year.	Quantity (long tons).	Value* (£).
1913	—	—
1914	—	—
1915	492	400
1916	3,808	3,412
1917	1,988	2,024

The production for 1918 is elsewhere stated as 2,569 tons.

Imports of Manganese Ore into Belgium (Principal Sources).†

From	1912. (India, 1912–13.)	1913. (India, 1913–14.)	1914. (India, 1914–15.)
	Quantity (long tons).	Quantity (long tons).	Quantity (long tons).
India	171,066	187,821	66,043
Russia (Tchiaturi) ...	193,500	182,500	154,467
Brazil	—	11,610	10,430

The following table shows the sources and ultimate destinations of manganese ore imported into Belgium during the first six months of 1914‡ :—

Source of Supply, or Destination.	Imported into Belgium.	Exported from Belgium.
	Quantity (long tons).	Quantity (long tons).
Germany	317	56,033
Brazil	10,430	—
Spain	9,564	—
Luxembourg (Grand Duchy) ...	—	2,233
British India	104,184	—
Portuguese India	6,986	—
Russia (Caucasus and Nikopol) ...	147,919	1
Other Countries	1,700	871
Total	281,100	59,138

Retained in Belgium (by difference) ... 221,962

In 1919, 55,304 tons of manganese ore were imported into Belgium.§.

* Values converted to £ sterling at the rate of 25 fr. = £1.

† Based on manganese ore exports of the respective countries.

‡ *Annales des Mines de Belgique*, 1920, *21*, 14. (Quoted from the Bulletin of Foreign Trade of Belgium, Ministry of Finance).

§ *Stahl u. Eisen*, Düsseldorf, 5th August, 1920, 1056.

The tonnage remaining for consumption in Belgium was abnormally large, and it is suggested that a large part of it was destined for Germany, who would expect to find it in stock at Antwerp after invading the country.

Deposits of manganese ore of good quality exist at Katanga, Belgian Congo, but these appear unlikely to be worked owing to their great distance from the coast.

France.

The total production of manganese ore in France immediately before the war was 5,486 long tons in 1912, and 7,608 tons in 1913, the output coming chiefly from the Vieille-Aure (Hautes Pyrénées) and Romanèche (Sâone-et-Loire) mines.* No later statistics of the domestic production appear to have been published. In 1890, the Romanèche mine had an output of nearly 14,000 tons of manganese ore, but by 1909 its production had fallen to 3,783 tons.† Fuchs and De Launay‡ describe the ore at this mine as barytiferous psilomelane containing about 60 to 70 per cent. of manganese oxide with 13 per cent. of baryta. The deposits consist of a series of fissure veins, while there are also some pockets, somewhat resembling the "flats" of lead veins in the North of England, which appear to be partly contact deposits and partly cavity-fillings in limestones of Liassic age.

The Las Cabasses mine in the Department of Ariège (Pyrénées) produced considerable quantities of carbonate ore between 1892 and 1896, but operations were suspended in 1904. In 1908, however, nearly 6,000 long tons of the ore were mined, and in 1909 nearly 1,400 tons (L. De Launay, *loc. cit.*).

Some silicate of manganese mines in the Hautes-Pyrénées, such as the Louderville, Adervielle and Vieille-Aure, produce ore which is treated electrically at Villelongue near Pierrefitte (*ibid.*)

Production of Manganese Ore in France.
(*Statistique de l'Industrie Minérale.*)

Year.	Quantity (long tons).
1913	7,608
1914	6,290
1915	10,158
1916	10,633
1917	11,403
1918	9,712
1919	4,738

The production of manganese ore in 1920 has been reported as 5,605 tons.§

* L. Guillet, Organization of French Production after the War, Paris, 1918, 1st Section, 60; and The French Year Book, Paris and London, 1919, 730.
† L. De Launay, *Gîtes Minéraux et Métallifères*, Paris and Liége, 1913, *2*, 529.
‡ *Traité des Gîtes Minéraux et Métallifères*, Paris, 1893, *2*, 15.
§ Preliminary statistics, *Administration des Travaux Publics* (Paris).

Production of Ferro-manganese in France.
(Statistique de l'Industrie Minérale.)

Year.	Quantity (long tons).
1913	—
1914	15,303
1915	3,811
1916	14,148
1917	12,886
1918	10,992
1919*	77 (over 80 per cent. manganese) 19,019 (under ,, ,, ,,)

French Imports and Exports of Manganese Ore.
(*Le Commerce de la France, Ministère des Finances*, Paris, Annual.)

Year.	Imports.		Exports.	
	Quantity (long tons).	Value.†	Quantity (long tons).	Value.†
		£		£
1913	254,768	932,160	1,678	6,120
1914	151,020	552,560	404	1,480
1915	12,389	50,360	39	160
1916	57,716	469,280	271	2,200
1917	76,113	773,560	107	1,080
1918	58,036	613,440	32	360
1919	103,306	1,091,920	1,288	13,600

The following table shows the principal sources of the French imports and destinations of the exports of manganese ore in 1913 :—

(L. Guillet, *op. cit.*)

Imports.		Exports.	
From	Quantity (long tons).	To	Quantity (long tons).
India	86,630	Germany	1,021
Belgium	1,631	Italy	1,203
Russia	134,829	Switzerland	538
Spain	24,049	Other Countries ...	328
Brazil	7,098		
Indo-China	430		
Other Countries ...	1,790		
Total	256,457	Total	3,090

The totals are both in excess of those for 1913 published officially at an earlier date.

* Includes Alsace-Lorraine. Figures for year as reported by *Comité des Forges de France*. In the same year, 12,492 long tons of spiegeleisen were produced.
† Values converted to £ sterling at the rate of 25 francs = £1.

As will be seen from later tables, exports of manganese ore to France from Russia and Brazil ceased for the period of the war soon after its outbreak, but continued on a reduced scale from India.

French Imports and Exports of Ferro-Manganese.

(*Le Commerce de la France, Ministère des Finances*, Paris, Annual.)

Year.	Imports.		Exports.	
	Quantity (long tons).	Value* (£).	Quantity (long tons).	Value* (£).
1913	14,163	172,720	3,775	39,920
1914	5,082	61,960	3,255	34,400
1915	6,873	166,520	2,464	59,680
1916	5,292	258,160	1,553	75,760
1917	6,257	356,080	1,267	72,160
1918	9,560	680,160	324	23,000
1919	11,502	818,320	761	54,120

The ferro-manganese exported was produced in electric furnaces.

The principal sources and destinations of ferro-manganese imported into and exported from France in 1913 were as follows :—

(L. Guillet, *op. cit.*)

Imports.		Exports.	
From	Quantity (long tons).	To	Quantity (long tons).
England	9,617	England	1,651
Germany	4,498	Belgium	1,351
Other Countries ...	100	Russia	305
		Other Countries ...	519
Total	14,215	Total	3,826

The totals differ slightly from those for 1913 published officially at an earlier date.

Germany.

The deposits of manganese ore in Germany are of very small economic importance, only a few hundred tons having been obtained annually before the war, this output coming from a

* Values converted to £1 sterling at the rate of 25 francs = £1.

deposit at Giessen, Hesse-Darmstadt. Manganiferous iron-ores, however, occur extensively, and have been worked on a large scale, more particularly during the war period, for the production of low-grade ferro-alloys. Prior to 1914, the German steel industry depended for practically all of its manganese ore requirements on imports from Russia. The manganiferous iron-ore deposits of Hesse-Nassau, from which such mineral was principally obtained, have been stated to contain not more than 20 per cent. of manganese, with 30 to 35 per cent. of iron, there being large quantities of poor ore carrying 12 to 15 per cent. of manganese.* Early in 1915, deposits in the Siegen and Nassau regions (manganiferous iron-ore, containing 15 to 20 per cent. of manganese), which had hitherto been considered not worth working, were extensively developed for the production of a low ferro-alloy containing 30 to 40 per cent. of manganese, the slags being resmelted to enrich them in manganese and then used as fluxes.† The Siegerland mines were said during the war to be yielding about 1¾ million tons yearly of manganiferous ore containing 12 per cent. of manganese,‡ the total output of the district in 1915 being about 2¼ million tons, most of which was used in the manufacture of spiegeleisen.§

The output of manganiferous ore in Germany for 1912 was 90,988 long tons, valued at 12*s.* 10*d.* per ton, this production having been obtained in the neighbourhood of Coblenz,‖ where the ore occurs usually as pockets in limestone.

Complete statistics of the domestic production for the period 1913-1919 are not yet available, but, so far as can be ascertained the Prussian production was as follows :—

Prussian Production of Manganese Ore.

(*Zeits. f. das Berg-, Hütten- und Salinenwesen*, Berlin, 1920, *68*, 18.)

Year.	Quantity (long tons).	Value§ (£).
1913	—	—
1914	—	—
1915	—	—
1916	939	5,523
1917	598	11,360
1918	1,017	21,888
1919	544	22,732

The production for 1913 is elsewhere stated to have been 748 tons.

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* L. De Launay : *op. cit.*, *2*, 528.
† *L'Echo des Mines*, 12th November, 1916.
‡ The Mineral Industry, New York, 1916, *25*, 495.
§ *Ibid.*, 195, *24*, 493.
‖ Production of Prussian Mines, Salt-Works and Smelters of the Prussian States (Annual) : Berlin.

In 1913, Germany imported 669,436 long tons of manganese ore, as against 514,718 tons in 1912. The sources of supply, quantities, and values of the ore imported in 1913 are shown below :

Imports of Manganese Ore into Germany, Year 1913.

(*Statistisches Jahrbuch für das Deutsche Reich*, Berlin, 1914, 201.)

From—	Quantity.		Value.*	
	Total (long tons).	Per cent. of total.	Total.	Per ton.
			£	*s.* *d.*
British India, etc. ...	174,783	26·1	444,100	50 10
Russia	439,760	65·7	871,550	39 8
Spain	27,026	4·0	53,550	39 7
Brazil	21,521	3·2	55,800	51 10
Other Countries ...	6,346	1·0	16,350	51 6
Total	669,436	100.0	1,441,350	43 1

German imports of manganese ore for the first half of 1914 amounted to 385,580 tons.† On the outbreak of the war in August of that year, imports of such ore from Russia, Spain, India and Brazil, and of ferro-manganese from the United Kingdom, ceased, and the German steel industry had to look for its requirements of manganese ore to accumulated stocks, low-grade deposits within the Empire, contributions from Austria-Hungary, and such stocks as might be found in Belgium.

With the current exchange, Germany has been unable to buy any considerable quantity of foreign manganese ore since the conclusion of the war.

During the year 1913, 700,832 tons of manganese ore, containing over 30 per cent. of manganese, were smelted in Germany.‡

In 1917, German blast-furnaces consumed 45,258 tons of manganese ore containing over 30 per cent. of manganese, in addition to which large tonnages of manganiferous iron-ores were consumed for the production of spiegeleisen and other ferro-alloys.

Exports of manganese ore from Germany in 1913 amounted to 9,146 long tons, valued at £32,450 (71*s.* per ton), as against 7,765 tons, valued at £37,400 (96*s.* 4*d.* per ton), in 1912.§ These exports consisted largely, if not entirely, of high-grade dioxide for chemical uses, there being a considerable demand for such dixoide

* Values converted to £ sterling at 20 marks = £1.

† The Mineral Industry, New York, 1914, *23*, 518. Later statistics are not available.

‡ *Stahl u. Eisen*, 1917, 388.

§ *Statistisches Jahrbuch für das Deutsche Reich*, Berlin, 1914, 201.

in the United States, the United Kingdom and certain other countries. Exports of this material to the United States continued on a decreasing scale until 1915.

On the outbreak of the war, Germany was no longer able to obtain the foreign imports of ferro-manganese on which her steel industry so largely depended, and great efforts were made to find effective substitutes for that alloy as a deoxidizer and recarburizer of steel. Among the " common deoxidizers " tried were alloys of aluminium and silicon, while calcium, sodium, vanadium, uranium and boron alloys were also used, although their cost was excessive and, when not assisted by one or more of the common deoxidizers, the steel produced was not of good quality. The greatest hopes were based on calcium carbide, but persistent tests on a large scale proved unsuccessful. It is regarded as unlikely that manganese will be replaced to any important extent in the manufacture of steel in Germany or elsewhere in normal times.

Greece.

Deposits of manganese ore occur in Milos and Andros, the mineral on the former island containing about 30 per cent. of manganese, while that of the latter ranges from 25 to 35 per cent.* The only important deposit of such ore in Milos is that of Chalaka, at Cape Vani, in the N.W. of the island, where the mineral occurs intercalated between liparite and argentiferous barite of Miocene age.†

L. Demaret‡ gives the percentage composition of 15,000 tons of manganese ore produced in Milos in 1902 as :—manganese, 42 to 52 ; iron, 1 ; silica, 8 to 12 ; phosphorus, 0·09 to 0·10.

Manganiferous iron-ore is mined in the Laurion district, at the south-east end of the peninsula of Attica, the mineral won by the Compagnie Française de Laurium averaging about 12 per cent. of manganese and 30 per cent. of iron, while analyses of the ore at the Nikias mine, owned by the Société des Usines de Laurium, show 14 per cent. of manganese, 0 to 34 per cent. of iron, and 6·62 to 8 per cent. of silica. The ore occurs at the base of the middle limestone, or in the upper limestone, as zones of carbonate of manganese and iron, sometimes with a little disseminated galena and pyrite. Weathering has altered the carbonate to pyrolusite, which is found in beds sometimes of considerable thickness, or to psilomelane, which fills transverse fissures in the limestone.§ About 1894, some 60,000 tons of manganiferous iron-ore from Laurion were exported to Belgium,

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* *Statistique du Mouvement Minier de Grèce* (Annual) : Athens.

† L. De Launay : *op. cit.*, *2*, 538.

‡ *Les principaux gisements des minerais de manganèse du monde : Ann. des Mines de Belgique*, Brussels, 1905, *10*, 66.

§ L. De Launay : *op. cit.*, *2*, 538.

for use in basic converters, this containing from 15 to 18 per cent. of manganese with slight proportions of lead and phosphorus; but the production of the district fell rapidly after that year.

There appears to have been no production of manganese ore in Milos and Andros in 1913 and 1914, but 547 long tons of such ore were sold out of stock in the former year and 549 long tons in the latter. In 1918, 4,690 tons of manganese ore were exported from Greece, after an interval of three years in which no shipments appear to have been made. The production of manganiferous iron-ore in recent years has been obtained entirely from the mines at Laurion owned by the Compagnie Française de Laurium.

Production of Manganese Ore and Manganiferous Iron-Ore in Greece.

(*Statistique du Mouvement Minier de Grèce.* Annual.)

Year.	Manganese Ore.			Manganiferous Iron-Ore.		
	Production	Sales.		Production	Sales.	
	Quantity (long tons).	Quantity (long tons).	Value per ton.*	Quantity (long tons).	Quantity (long tons).	Value per ton.*
			s. d.			*s. d.*
1913	—	547‡	8 11·2	6,221	21,132	7 11·1
1914	—	549‡	9 8·8	1,294	8,354	12 1·0
1915	401†	—	—	1,024	5,028	10 8·4
1916	3,542†	—	—	805	—	—
1917	—	—	—	501	3,001	13 5·6
1918	5,045	4,690	36 9·8	961	4,726	8 10·2
1919						

Italy.

Deposits of manganese ores occur in Liguria, Tuscany, the island of San Pietro (off the south-west coast of Sardinia), and elsewhere in Italy; but, owing to the generally high percentage of silica which the ores contain, and to unfavourable transport conditions, the production from these deposits has never been very large. Early in 1920, however, the proposed import of Caucasian manganese ore was strongly criticized in the Italian Press, on the ground that the deposits in Sestri Ponente and

* Values converted to £ sterling at the rate of 25 francs = £1.
† Andros. ‡ Milos.

Cicagna (Liguria), Borghetto (Milan), and elsewhere in the kingdom should be developed.*

On the island of San Pietro, at Capo Becco and Capo Rosso, two beds of manganese ore, 8 inches and 2 feet in thickness respectively, occur within a series of trachytic tuffs and red and white clays, the beds being separated by about 6½ feet of clay. The ore, which consists chiefly of pyrolusite with a little hausmannite, is of high grade, containing about 60 per cent. of manganese, and has found a considerable sale for chemical uses, the annual production being estimated at about 1,000 tons.† The same authority (*loc. cit.*) has described several bedded deposits of manganese ore in the Eocene strata of Liguria, and in the Devonian of Tuscany. Manganiferous limonites occur near veins of complex sulphides at Monte Argentario, in the province of Grosseto, Tuscany, intercalated between lower Liassic limestones and Permian schists.‡ These deposits have been worked since 1874, the output going chiefly to England for the production of ferro-manganese. The richer ore produced is stated to have contained from 30 to 39 per cent. of manganese and 4 to 11 per cent. of iron, while the poorer material contained about 18 per cent. of manganese and 30 to 35 per cent. of iron. In 1916, 686 long tons of manganese ore averaging 31 per cent. of manganese, and in 1917 5,229 long tons, averaging 33 per cent., were mined in the province of Grosseto.§

Manganiferous beds in the province of Siena, Tuscany, have recently been described.‖ A typical bed occurs at Rapolano, in Siena, in Eocene strata. In the La Silva locality, the working of such a formation was attempted years ago, but, owing to the excessively high percentage of silica and the low percentage of manganese, operations here were abandoned. During the war, however, the same formation was profitably exploited in the locality of Monte Martino, nearer to Rapolano, where an old working from which some 15,000 long tons of ore were extracted about 1873 was re-opened. Here beds of ore 12 to 16 inches in thickness occur in sharply folded argillaceous rocks. From the middle of 1916 to the end of 1918 about 15,000 long tons of ore, averaging 25 per cent. of manganese and about 25 per cent. of silica, were produced from these beds. It is estimated that a monthly production of 300 to 400 tons could be maintained from the present surface trenches, and that a grade of ore, approaching 50 per cent. of manganese and 18 per cent. of silica, might be obtained by selection.

The domestic production of manganese ore was stimulated by the entry of Italy into the war in 1915, as will be seen from the following table :—

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* The Mining Journal, London, 1920, *129*, 339.
† L. Demaret, *loc. cit.*, 68.
‡ L. De Launay, *op. cit.*, 539.
§ *Revista del Servizio Minerario* (Annual), Rome.
‖ *Rassegna Mineraria, Metallurgica e Chimica*, Rome, 1920, *52*, 60–62.

Production of Manganese Ore in Italy.

(*Revista del Servizio Minerario*, Rome. Annual.)

—	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Quantity, long tons	1,596	1,622	12,375	17,855	24,138	31,383	30,345
Average percentage of manganese.	45·00	44·42	28·11	26·15	35·91	35·86	35·40
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Average value per long ton.	30 10·5	27 0	31 2	28 0	61 4	74 5·9	71 10·8
	£	£	£	£	£	£	£
Total value* ...	2,464	2,189	19,290	25,005	74,012	116,891	109,104

In 1913-1914 the production came wholly from the Carrara mining district (province of Genoa) and the Iglesias district (province of Cagliari). In 1915 these districts continued to yield outputs, while the provinces of Livorno, Siena, and Pisa (Firenze mining district) also contributed, the first two on a relatively large scale. In 1916 the production for Siena showed a considerable increase, amounting to nearly 10,000 tons, although the average content of manganese was only 20 per cent. In the same year the province of Grosseto, in the Firenze district, produced nearly 700 long tons of ore containing 31 per cent. of manganese, while other areas began to contribute in small amounts to the steadily increasing total production. The following table gives details of the manganese ore production for 1917 :—

Production of Manganese Ore in Italy, by Provinces (1917).

(*Revista del Servizio Minerario*. Annual.)

Mining district.	Province.	Quantity (long tons).	Manganese (per cent).	Value.*	
				Total.	Per ton.
				£	*s. d.*
Carrara ...	Genoa ...	4,113	45·00	10,868	52 10
Firenze ...	Grosseto ...	5,229	33·00	19,134	73 2
	Livorno ...	3,622	29·00	9,946	54 11
	Siena ...	5,805	30·00	11,840	40 9
Iglesias ...	Cagliari ...	3,134	38·70	13,498	86 2
	Sassari ...	70	50·00	426	121 8
Napoli ...	Cosenza ...	2,165	44·00	8,300	76 8
	Total ...	24,138	—	74,012	—

The production of manganese ore in 1920 has been provisionally reported as 28,672 tons.†

* Values converted to £ sterling at the rate of 25 lire = £1.

† *Ministero di Agricoltura, Industria, e Commercio*, Rome.

There was no production of manganiferous iron-ore in Italy during the period 1913-1915. The figures for later years are as follows :—

Production of Manganiferous Iron-Ore in Italy.

(*Revista del Servizio Minerario.* Annual.)

Mining district.	Province.	1916.			1917.			1918.		
		Quantity (long tons).	Percentages of iron and manganese.	Value* per ton.	Quantity (long tons).	Percentages of iron and manganese.	Value* per ton.	Quantity (long tons).	Percentages of iron and manganese.	Value* per ton.
				s. d.			*s. d.*			*s. d.*
Carrara	Lucca ...	3,517	Fe 40·00 Mn 8·00	20 4	1,507	Fe 40·00 Mn 8·00	20 4	792	Fe 40·00 Mn 8·00	20 4
Firenze	Grosseto	675	Fe 29·00 Mn 10·00	16 3	3,202	Fe 30·00 Mn 10·00	28 5	—	—	—
	Livorno	98	Fe 13·00 Mn 14·00	20 4	20	Fe 23·00 Mn 14·00	24 4	—	—	—
	Total...	4,290			4,729			792		

In 1919, only 67 tons of manganiferous iron-ore, containing 40 per cent. of iron and 8 per cent. of manganese, were produced in Italy, the value per ton being returned as 28*s.* 4*d.*

Before the war the ferro-manganese consumed in Italy was mostly imported, but at the outbreak of hostilities in 1914 several Italian works started the manufacture of this and other manganese alloys. In 1914 and 1915 the production of these alloys was confined to works at Darfo, Brescia province, Milan mining district, but in subsequent years manufacturers in other provinces contributed to the output, although Brescia continued to be by far the most important producer. Of the 12,709 long tons of so-called ferro-manganese produced in the year 1916, 5,508 long tons containing 80 per cent. of manganese were made in electric furnaces, while the whole of the small production of silico-manganese (containing 20 per cent. of silicon) was also produced by the electric furnace method.

* Values converted to £ sterling at the rate of 25 lire = £.

Production of Ferro-manganese and Silico-manganese in Italy.

(*Revista del Servizio Minerario.* Annual.)

Year.	Alloy.	Quantity (long tons).	Grade.		Value.*	
			Manganese.	Silica.	Total.	Per long ton.
			Per cent.	Per cent.	£	s. d.
1914	Ferro-manganese	1,101	—	—	16,326	296 6.8
1915	Ferro-manganese	1,330	80	—		650 5
		754	20	—		243 11
		1,512	10	—		227 7
	Total	3,596	—	—	69,670	—
	Silico-manganese	465	50	—		589 5
		72	20	—		447 2
	Total	537	—	—	15,323	—
1916	Ferro-manganese	5,508	80	—		975 7
		444	28	—		569 1
		1,647	20	—		528 5
		5,110	10	—		447 2
	Total	12.709	—	—	423,019	—
	Silico-manganese	844	—	20	38,622	915 2.6
1917	Ferro-manganese	6,219	78 to 80	—		1,219 6
		1,948	28 to 30	—		772 4
		1,954	18 to 20	—		609 9
		9,106	10 to 12	—		487 10
	Total	19,227	—	—	736,140	—
	Silico-manganese	744	50	25		975 7
		350	20	12		813 0
	Total	1,094	—	—	50,528	—
1918	Ferro-manganese	2,207	78 to 80	—		1,238 0
		492	28 to 30	—		772 4
		295	18 to 20	—		610 2
		3,818	10 to 12	—		487 10
	Total	6,812	—	—	297,734	—
	Silico-manganese	492	50	25		974 10
		1,224	20	12		451 6
	Total	1,716	—	—	51,632	—

* Values converted to £ sterling at the rate of 25 lire = £1.

Imports of Manganese Ore into Italy.

Year.	Quantity (long tons).
1913	—
1914	13,719
1915	15,715
1916	29,444
1917	21,192
1918	5,364
1919	8,357

In 1917, 13 long tons of manganese ore were exported from Italy, this being apparently the only shipment during the period under review.

Rumania.

An extensive deposit of manganese ore was recently reported to have been uncovered in the vicinity of Deznac-Mennyhaza, county of Arad, Rumania,* some 20 million metric tons being in sight. The quality is stated to resemble, but to be superior to, that of the manganese ore of Hesse-Nassau, and to be suitable for chemical purposes and the production of ferro-manganese and spiegeleisen. Deposits of manganiferous iron-ore, estimated at 36 million tons and said to contain 35 per cent. of iron, occur in north-western Moldavia at Brosteni in the valley of the Bistrita; but these are not yet being worked commercially.†

The manganese minerals of the Brosteni region and their geological associations have been described by V. C. Butureanu.‡ The group name " ponites " is given to manganese carbonates containing several per cent. of ferrous oxide which form veins in schists and other crystalline rocks in the region, while the name " brostenite " is given to compact hydrous oxides of manganese and iron associated with the carbonates. The deposits have not been extensively explored, but Butureanu estimates that 30 million tons of ore are available which would yield 10 million tons of ferro-manganese.

By the Treaty signed at Trianon, on 4th June, 1920, the Bukowina passed from the Austrian Empire to the Kingdom of Rumania. An account of the deposits of manganese ore in the Dorna Vatra district of the Bukowina, as investigated in 1913, is given on pp. 65-66.

Russia and Georgia.

Economically valuable deposits of manganese ore have been exploited (1) on the southern slope of the central part of the Caucasus mountains, near Tchiaturi in the valley of the river Kvirila, a tributary of the Rion, about 40 miles east of Kutais

* Mining Journ., London, 1920, *128*, 177.

† Rumania: British Foreign Office Historical Handbook, No. 23, 1920, 106.

‡ The Ores of Manganese and Iron of the Crystalline Massif of Brosteni, Rumania: *Soc. franc. min.* Bull., 1917, *40*, 164—177 (quoted by D. F. Hewett, Manganese and Manganiferous Ores in 1918, U.S. Geol. Surv., Min. Res. U.S. 649).

in the province of that name, which is now comprised in the independent Republic of Georgia constituted in November, 1917; (2) in the vicinity of Nikopol (government of Ekaterinoslav, South Russia), on the Dnieper river, about 100 miles from the Gulf of Odessa; and (3) in the central part of the Urals; while extensive deposits of pyrolusite occur in the Gaisinsk district, province of Podolia, south-west Russia.

By far the most important of the manganese ore-producing districts is Tchiaturi. In the 10 years 1904-1913, the annual production in the Caucasus averaged slightly over 600,000 tons, that of the Nikopol district in the same period averaging nearly 200,000 tons, while the annual output in the Urals and elsewhere was relatively unimportant, amounting to only a few thousand tons.* Of the Nikopol production about 80 per cent. was consumed by the South Russian steel industry, the remainder going normally to Germany,† whereas the great bulk of the Tchiaturi output has normally been exported. The Russian manganese ore mining industry has always been much handicapped by inadequate railway facilities, and, so far as the Tchiaturi deposits are concerned, by the insufficiency of berths for steamers loading at Poti; while the mining methods and the administration have been greatly inferior to those characterizing the Indian manganese ore industry.

According to N. T. Belaiew and S. I. Atchkassoff,‡ the output of manganese ore in the chief producing districts of Russia for the three years immediately preceding the war and the first three years of the war period was as follows :—

(Quantities : long tons.)

Year.	Urals.		South Russia.		Caucasus.		Total.
	Total.	Per cent. of total.	Total.	Per cent. of total.	Total.	Per cent. of total.	
1910	903	0·3	175,323	27·8	545,242	71·9	721,468
1911	2,419		199,016		461,855		663,290
1912	3,145		234,823		569,339		807,307
1913	19,177	1·6	261,097	21·1	954,645	77·3	1,234,919
1914	3,548	0·4	235,484	26·4	652,355	73.2	891,387
1915	3,226	0·6	271,839	51·4	253,823	48·0	528,888

Certain of the figures for 1913-1915 differ appreciably from those given by other authorities, but the tonnages for the Caucasus agree closely with those given by Ghambashidze (*op. cit.*).

* M. Stromberg, Eng. and Min. Journ., New York, 1916, *101*, 894.

† The Russian Year Book, London, 1916, 232.

‡ The Russian Economist : Journal of the Russian Economic Association in London, 1921, *1*, No. 2, 297. (Quantities converted to long tons at the rate of 62 poods=1 ton.

Tchiaturi Deposits.—These have been described by several authorities. According to D. Ghambashidze,* the total area of ore-bearing lands is about 400 square miles, of which one-half contains good ore, the quantity available for exploitation being estimated at about 200 million tons. This estimate is very considerably higher than that given by other authorities, including Beyschlag, Vogt and Krusch,† who state that the present surface area of the whole deposit, of which about one-half has been removed by erosion, has been estimated by different authorities at between 120 and 143 square kilometres, so that the area of the available deposit must be at least 60 square kilometres (about 23 square miles). Each square metre yields on an average 0·96 ton of ore, and the total reserves on the basis of the present development have been reckoned at 110 to 115 million tons. This estimate, however, is said to be too high, since the thickness of the bed is subject to variation. E. C. Harder‡ adopts an estimate of 110 million tons, but H. K. Scott§ puts the amount available for exploitation at 22 million tons. A more recent estimate (the authority for which is not stated) gives the reserves as 45 million tons.§§

The geological conditions, according to Beyschlag, Vogt and Krusch,‖ are briefly as follows: A tableland of Upper Cretaceous limestone and slate forms the base for Eocene sandstone, etc., and Oligocene and Miocene sandstone, slate, and limestone. The beds lie almost horizontally, dipping on an average 2½° north-east. The manganese ore-deposit, which lies near the surface of this plateau and is cut with great regularity by valleys, belongs to the Lower Eocene, and lies a little above the contact with the Upper Cretaceous. Sandstone occurs both in the hanging-wall and in the foot-wall. The whole deposit represents a shallow-water formation. The thickness is generally 5 to 8 feet, averaging 6·9 feet. Within this thickness from 5 to 12 manganiferous layers occur in alternation with marly sands, which in part are also impregnated with ore. These manganiferous layers consist of oolitic material in a matrix of fine-grained ore. The hard layers contain on an average 56 per cent. of manganese, while the softer layers, in consequence of their association with barren material, are poorer. According to the same authorities, the ore as delivered for shipment usually contains from 50 to 52 per cent. of manganese (reckoned with ore dried at 100°C.), 6 to 8 per cent. of silica, only 1 to 2 per cent. of iron, and 0·05 to 0·17 per cent. of phosphorus.

The Tchiaturi ore is composed mainly of pyrolusite, and is very soft. Psilomelane and wad also occur. In some places, according to F. Drake,¶ the ore contains, without sorting

* Mineral Resources of Georgia and Caucasia, London, 1919, 132.
† *Op. cit.*, 2, 1105. ‡ Trans. Amer. Inst. Min. Eng., New York, 1916, *56*, 38.
§ Bull. Amer. Inst. Min. Eng., No. 120, 1916, 2223.
§§ Eng. and Min. Journ., New York, 1920, *109*, 1111.
‖ *Op. cit.*, 1105.
¶ The Manganese Ore Industry of the Caucasus: Trans. Amer. Inst. Min. Eng., 1898, *28*, 191–208.

or cleaning, from 48 to 52 per cent. of manganese, but the average percentage is 40 to 45. Concentrates of exceptional purity, prepared by washing for use in chemical industries, contain 80 to 90 per cent. of manganese dioxide. As a general rule, the exported ore which has undergone sorting averages 51 to 52 per cent. of manganese. Where the barren material has been thoroughly separated, concentrates may carry as high as 61 per cent. manganese. Phosphorus averages about 0·16 per cent., and silica not more than 8 per cent. The proportion of large pieces obtained is low, and much of the ore is very soft, disintegrating to a fine powder during mining, cleaning and transportation. The ore shipped contains so high a percentage of fines on delivery that much of it is unsuitable for use in blast furnaces, rendering mixture with other manganese ores necessary before charging.

Ghambashidze (*op. cit.*, 133) gives the following complete analyses of Tchiaturi ore samples :—

	(1)	(2)	(3)
	Per cent.	Per cent.	Per cent.
Moisture	2·40	1·61	1·20
Silica	4·49	6·67	2·88
Alumina	1·68	2·14	2·34
Ferric oxide	0·53	0·03	
Manganese dioxide	85·67	85·77	84·90
Manganous oxide	1·98	0·80	2·50
Lime	0·76	0·87	0·33
Magnesia	0·20	0·24	0·32
Baryta	0·88	0·68	3·11
Sulphur trioxide	–	–	1·19
Phosphorus pentoxide ...	0·42	0·40	0·35
	99·01	99·21	99·12
Equivalent to			
Manganese	55·70	54·83	56·60
Phosphorus.	0·18	0·17	0·15

According to the same authority, the average assay of actual cargo deliveries is usually about 53 per cent. of manganese in the dry state.

Most of the Tchiaturi ore is delivered by railway to Poti or Batum, on the Black Sea, the distance from the mines to the former port being about 90 miles and to the latter about 126 miles. Transportation from the various mines to Tchiaturi station (1·3 to 3·3 miles) is done by means of ox-carts or pack-horses, owing to the bad condition of the roads, while the 26-mile branch line connecting Tchiaturi with Sharopan, the nearest railway station on the main railway, is a narrow-gauge track, this necessitating the transfer of the ore at that station to the broad-gauge trucks of the main line, an operation adding considerably to the cost of transport and resulting in further disintegration of the ore. The cost of mining and cleaning the ore has normally been 6*s*. 0·5*d*. per ton; road and railway transportation : to Poti, 14*s*. 8*d*. per

ton, and to Batum, 16*s.*; port charges, taxes, etc., at Poti, 3*s.* per ton; port charges at Batum, about 1*s.* 11*d.*, making the total cost of the ore delivered at Poti 23*s.* 8·5*d.*, and at Batum 23*s.* 11·5*d.* per ton.*

The following is an approximate estimate,† based on the freight and other charges at the end of May, 1920, of the present cost per ton (wet weight) of Tchiaturi manganese ore intended for the metallurgical industry, *f.o.b.* Poti :—

	Per ton.	
	s.	*d.*
Mining, dressing, transport, and loading on rail	5	6
Railway freight, Tchiaturi to Poti	14	8
Handling at Sharopan	1	0
Station and weighing charges, port dues, and loading on board	3	0
Association of Producers' tax	2	0
Total	26	2

This is equivalent to about 7*d.* per unit on ore averaging 50 per cent. of manganese, dry weight.

The tax on ore destined for the chemical industry is 4*s.* per ton.

After realization at the port of destination, and the deduction from the sum realized of all freight and other charges, the Georgian Government tax of 25 per cent. of the net profit, and the amount already advanced against the ore *f.o.b.* Poti, any balance is paid to the producer by the special committee authorized by the Government and known as the Manganese Producers' Company.

It is generally impossible to extract the ore free from admixture with clay. At some mines the lump ore is picked out by hand, mostly in the open; at others it is screened to remove the siliceous gangue and then roughly concentrated on tables or by jigging. The ore thus prepared is classified as "very rich," "rich," and "medium," the sorting process yielding about 33 per cent. suitable for shipment.‡

The Tchiaturi deposits appear to have been discovered in 1848, but there was no production of ore until 1879, when 871 tons were shipped. The United Kingdom was the first importer of the ore on a large scale, taking 40 per cent. of the total quantity exported between 1885 and 1898, after which Germany became the chief purchaser.

The most important of the numerous companies exploiting the Tchiaturi deposits before the war were the Schalker Gruben und Hütten Verein, of Gelsenkirchen, Germany; Forwood Bros., England; Panassie (France); and the Industrial and Commercial

* E. C. Harder: *loc. cit.*

† W. H. Rundall, The Manganese Deposits of Tchiaturi, Caucasus: The Mining Magazine, London, 1920, *23*, 150–155.

‡ Eng. and Min. Journ., New York, 1917, *104*, 647.

Company, of Antwerp. The last-mentioned company is stated* to have had a plant capable of producing 100,000 tons of 53 to 54 per cent. washed manganese ore per annum. According to the British Consul at Batum † the washing plants at Tchiaturi in 1916 were capable of producing 45 million poods (about 725,800 long tons) of manganese ore per annum, and several new plants were being installed.

Nikopol Deposits.—The manganese ore-deposit at Nikopol, South Russia, occurs in Oligocene rocks, close to the surface; it is horizontally bedded and has glauconitic clay and sand in roof and floor. Immediately beneath the Oligocene, granite or gneiss occurs, while at Horodizce, about 11 miles north of Nikopol, a Tertiary manganese ore-deposit lies almost immediately on granite. The deposit at Nikopol, which is very similar to that at Tchiaturi, is from 1 to 6 feet (averaging 3 to 5 feet) in thickness; the manganiferous area is estimated at 20 square kilometres (about $7\frac{3}{4}$ square miles) and the ore-reserves at 7·3 million long tons.‡ H. K. Scott and others are of the opinion that the quantity of ore available is many times greater than this. The ore-bearing layer consists of sandy clay, which contains nodules of psilomelane with smaller amounts of pyrolusite,§ the better class of ore assaying about 57 per cent. manganese. According to Belaiew and Atchkassoff (*loc. cit.*), the ore is clean lump averaging about 50 per cent manganese and 12 per cent. silica, the phosphorus content being sometimes as high as 0·25 per cent. These authorities give the estimated reserves of workable ore as approximately 700,000,000 poods (about $11\frac{1}{4}$ million long tons). In 1913 the South Russian district, in which the principal deposit is that at Nikopol, produced about 21 per cent. of the total Russian output of manganese ore, and of this quantity about 80 per cent. was used by the South Russian metallurgical works, leaving a balance of 20 per cent. for export. In pre-war years the bulk of the exported ore went to Germany, about two-fifths being shipped from Nicolaief on the Black Sea, the remainder being sent by rail across the western frontier. Before the war, the Russian steel industry was able to obtain most of its supplies of manganese ore from the Nikopol mines, but, owing to the greatly increased demands of that industry in 1916, the bulk of such supplies had to be obtained from Tchiaturi.

Ural Deposits.—Manganese ore has been produced in the Ural district since 1882, but the average annual output during the present century, before the war, appears to have been only about 5,000 tons. In 1913 the production amounted, exceptionally, to over 19,000 tons, but averaged only about 3,400 tons for the years 1914 and 1915. Later statistics are not available. The main deposits in this district are stated by Belaiew and

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* S. H. Ball and B. Low; Eng. and Min. Journ., 1917, *103*, 410.
† Board of Trade Journ., London, July 19, 1918.
‡ Beyschlag, Vogt and Krusch; *op. cit.*, 1106.
§ A. M. Stelzner and A. Bergeat; *Die Erzlagerstätten*, Leipzig, 1904–6, 259.

Atchkassoff (*loc. cit.*) to consist of manganiferous ores containing only about 12 per cent. of manganese. The output is consumed in the local blast-furnaces, and the steel works very often require ferro-manganese to be imported from South Russia and sometimes from abroad.

Podolia Deposits.—Deposits of pyrolusite, said to be of large size and high grade, occur in the Gaisinsk district, province of Podolia, south-west Russia, the manganiferous region being reported to have an area of about 30 square miles. The district is situated about 220 miles by rail from Odessa. The working of the Gaisinsk deposits commenced in 1915, in which year about 450 tons of ore were delivered to South Russian blast-furnaces.

The first cargo of Caucasian (Tchiaturi) ore that reached the United Kingdom after 1914 is stated to have been delivered to the United Steel Company's works at Workington in May, 1920. The quantity was 7,000 tons, its value delivered being £84,000. The value of this cargo before the war would have been £11,200.* This ore was probably shipped *ex* stock. According to a United States Commerce Report,† there was no production of manganese ore in the Caucasus in 1918 or 1919. Manganese is at present a Government monopoly, and exportation is possible only by special agreement—a condition resulting in the stagnation of trade.

For Tchiaturi ore bought f.o.b. Poti, the special conditions usually adopted in British Sale Contracts before the war were, shortly, about as follows‡ :* The price of the ore to be . . kopek per pood (36·1128 lb.) of ore dry weight, delivered f.o.b. steamer at Poti in bulk. The ore to contain 48 per cent. of manganese when dried at 212°F., any shipment containing less than 46 per cent. being subject to refusal by purchasers, other percentages to be paid for proportionately. The normal amount of silica to be 10 per cent. with a scale of 3*d.* per unit per ton above and below that amount, the maximum allowed being 11 per cent. The maximum amount of phosphorus to be 0·18 per cent. All moisture to be deducted from weight.

American steelworks made their contracts for Tchiaturi ore before the war at a fixed and progressive price per unit of manganese, the ore not to contain more than 8 per cent. of silica, nor more than 0·25 per cent. of phosphorus. In case of an excess, the following penalties were stipulated : For each 1 per cent. in excess of 8 per cent. of silica 15 cents (7½*d.*) per ton were deducted, and for each 0·02 per cent., or fraction thereof, in excess of 0·25 per cent. of phosphorus a deduction of 2 cents (1*d.*) per unit of manganese per ton was made. Ore containing

* The Financial Times, London, May 26, 1920.
† 1920. *90*, 321.
‡ D. Ghambashidze : *op. cit.*, 150.

less than 40 per cent. of manganese, or more than 12 per cent. of silica, or more than 0·27 per cent. of phosphorus, could be refused by the purchasers. Analyses to be made on samples dried at 100°C., and all moisture found in the sample as taken to be deducted from the weight (*op. cit.*).

Eighty per cent. of the manganese mines in the Tchiaturi district are owned by a large number of Georgians, who, in the early years of the industry, exploited them in an unintelligent and wasteful manner, each owner working independently. Difficulties soon arose, more particularly with regard to transport of ore in the steep and narrow valleys. Eventually an Association of Manganese Producers and Dealers was formed, under the auspices of the Russian Government, to organize the transport facilities by road or mechanical means, and generally to supervise the industry. The membership of this Association comprised all producers mining at least 1,600 tons of ore, and all dealers exporting not less than 5,000 tons per annum.* Up to 1914, the Association had failed to secure from the Government anything beyond promises of improvement of the transport difficulties.†

Towards the end of 1919 about 1,600,000 tons of manganese ore containing from 50 to 90 per cent. of manganese dioxide awaited shipment on the quays at Poti. At that date, the recently formed association known as the Chemo, or Manganese Producers' Company, appears to have represented only one-fourth of the concessions, nearly all the remainder being in the hands of two firms, Tchilingiurian Frères and M. Manuelides, of Batum.‡ At about the same time a United States consular report gave the stocks of cleaned ore at Poti and Tchiaturi as 58 million poods (about 935,500 long tons), of which the Manganese Producers Company held 15 million poods (about 242,000 tons), the remainder being held by the two firms mentioned above.

In a recent report of the Société de Darkvéti, which has leased its deposits in the Tchiaturi region to a Russian firm, it was stated that from December, 1919, to October, 1920, 145,000 metric tons of manganese ore were shipped from Poti *ex* stocks, the accumulation of which, together with the strict Labour laws, had delayed the resumption of production at the mines until the beginning of July, 1920. In pursuance of the monopoly granted to the Georgian Government, the latter granted to the Chemo, or Manganese Producers' Company, the sole right to export the ore, and it was thus possible to regulate prices. The export duty fixed by the Government is, however, very heavy, being always equal to, and sometimes more than, 50 per cent. of the profit realized on sales. This heavy burden, due to the

* D. Ghambashidze : *op. cit.*, 173.
† Caucasia : British Foreign Office Historical Handbook, No. 54, 1920, 66.
‡ *L'Echo des Mines et de la Métallurgie*, October 19, 1919, 611.

financial straits of the Republic, has seriously affected the industry.*

Production of Manganese Ore in Russia.

Complete production statistics for the period under review are not available, but it is known that the Russian manganese-mining industry was severely affected by the closing of the Russo-German frontier, and that production rapidly decreased on the subsequent closing of the Dardanelles, the greatly increased manganese ore requirements of the domestic iron and steel industries being largely, if not for the most part, supplied out of accumulated stocks after 1916.

So far as can be ascertained, the total actual production in Russia during 1913-15 was approximately as follows :—

Year.	Quantity (long tons).
1913	1,234,900
1914	891,400
1915	528,900

Statistics showing the total production of manganese ore in Russia during the remainder of the period under review are to some extent speculative, but D. Ghambashidze (*op. cit.*) gives what appear to be trustworthy figures showing the production of Georgia alone during the whole period, as follows :—

Year.	Quantity (long tons).
1913	954,645
1914	652,354
1915	258,220
1916	247,000
1917	201,380
1918	150,000

According to the British Consul at Batum (*loc. cit.*), there was a remarkable revival of manganese mining in the Caucasus in 1916 owing to the unusually large demands of the Russian iron works, which were formerly able to obtain most of their supplies from the Nikopol mines in South Russia. During that year 155,660 long tons were sent from Tchiaturi inland by rail *viâ* Baku and 98,460 long tons went to Poti. Of the latter quantity rather less than one-half was for shipment by the Black Sea route to South Russia, the remainder going into stock at Poti. Judging from the total amount of manganese ore in stock in the Caucasus at the end of 1916 (about 900,000 long tons) it would appear that the production of ore in that year more than kept pace with the demand from the Russian market.

Exports of Manganese Ore from Russia.

Complete export statistics for the period under review are not available. In 1913, the total exports of manganese ore from

* The Min. Journ., London, 1921, *132*, 92.

Russia amounted to 1,152,180 long tons, and in 1914 to 725,450 long tons.*

Before the war, about three-fourths of the total Russian production came from Tchiaturi, and in 1913-14 the output of that region was distributed as follows :—

To	1913.		1914.	
	Quantity (long tons).	Per cent. of Total.	Quantity (long tons).	Per cent. of Total.
United Kingdom ...	246,500	23·1	107,030	15·8
Austria	25,400	2·4	32,435	4·8
Belgium...	182,500	17·1	154,467	22·8
France	55,100	5·2	23,951	3·5
Germany(*a*)	412,000	38·6	326,403	48·4
Italy	7,400	0·7	—	—
United States	137,700	12·9	34,548	5·1
Total exported ...	1,066,600	100·0	678,834	100·0
Used in Russia ...	10,000		15,096	

(*a*) In 1912, the Russian exports to Germany amounted to only 322,500 long tons.

About three-fourths of the exports of Tchiaturi ore to Germany were normally received in that country *viâ* Dutch ports, the remainder going to German ports.

According to D. Ghambashidze (*op. cit.*)†, the exports of Tchiaturi manganese ore from the ports of Poti and Batum amounted to 9,750 long tons in 1915 and to 9,769 tons in 1916.

Spain.

Manganese ores occur in the provinces of Ciudad-Réal, Gerona, Huelva, Murcia, Oviedo, Sevilla, and Teruel. According to official statistics, 837,000 tons of such ores were mined in Spain during the years 1881-1909, nearly all of this coming from the Huelva carbonate deposits, although work on these was practically suspended for the first ten years of that period. The annual production exceeded 100,000 tons during the period 1897-1900 but afterwards declined irregularly, averaging only 7,229 long tons for 1909-1911, but amounting to 17,120 tons in 1912. The production in subsequent years is tabulated. As a result of new discoveries and more intensive work during the war period, the yearly output has shown a considerable increase since 1916. Spanish manganese ore is commonly sold on the basis of its percentage content of manganese dioxide.

In addition to the production of manganese ore there has been a considerable output in the Cartagena region, province of

* Min. Ind., New York, 1915, *24*, 490.

† Data given by the Council of Congresses of Miners of Manganese Ore (quoted also by *The Iron Age*, New York, Jan. 27, 1917).

Murcia, of manganiferous iron ore containing from 10 to 20 per cent. of manganese and 20 to 25 per cent of iron, the mineral occurring in association with hæmatite. It is used only when the content of silica is not in excess of 10 per cent., most of the production going to England.

Province of Huelva.—The manganiferous deposits of this province have been described by Hoyer.* They are situated in south-western Spain, on the northern slopes of the Sierra Morena, in the same region as the Rio Tinto pyrites deposits. More than a hundred manganiferous deposits are known in the locality, these being in the form of lenticular masses conformably interbedded among clay-slates and porphyroids, and belonging in part at least to the Culm formation. The length of these masses is exceptionally over 3,000 feet, but seldom more than 500 feet, the breadth sometimes exceeding 300 feet, but averaging about 100 feet. For the most part the lenses consist of banded or massive compact rhodochrosite and rhodonite, associated with which are ferruginous silicates and chert. The carbonate and silicate ores are oxidized to pyrolusite and psilomelane for an average depth of about 65 feet below the surface. The carbonate ores contain from 28 to 45 per cent. of manganese, 3 to 7 per cent. of iron, and 5 to 15 per cent. of silica, while the silicate ores contain 39 to 45 per cent. of manganese and 20 to 22 per cent. of silica. In most of the ores the phosphorus content is less than 0·10 per cent.† Mining operations started in 1858, but, as mentioned above, were practically suspended between 1881 and 1891.

Prior to 1893 only the superficial oxidized ores were worked, but in that year the mining of primary ores was commenced. The annual output appears to have reached its maximum in 1900, when 111,083 long tons were produced. The production subsequently became almost insignificant, the known deposits of carbonate ore being to a large extent exhausted; but during the war some new workings were opened which have improved the output.

Province of Ciudad-Réal.—An occurrence of bedded manganese ore in the Miocene rocks of the plateau of La Serena, near Val de Peñas, has been described.‡ The ore consists in greater part of psilomelane, and is stated to contain from 40 to 60 per cent. (on an average 43 per cent.) of manganese, 1 to 20 per cent. of silica, 0·098 to 0·272 per cent. (on an average 0·25 per cent.) of phosphorus, 3 per cent. of oxide of iron and alumina, and 0·14 to 0·37 per cent. of cobalt. The deposit, which has an average thickness of about 4 feet, has hitherto been worked only in open cuts.

Province of Teruel.—Deposits of silicate ore, said to contain 33 per cent. of manganese and 30 to 37 per cent. of silica, were

* *Zeits. f. prakt. Geol.*, 1911, *19*, 407–432.

† D. F. Hewett, Production of Manganese and Manganiferous Ores in 1912, U.S. Geol. Surv. Min. Res. U.S.

‡ R. Michael, *Zeits. f. prakt. Geol.*, 1908, 129–130; L. De Launay, *op. cit.*, *2*, 565

discovered in this province a few years ago, and ore therefrom has been shipped to Belgium and Luxembourg for smelting with aluminous iron-ores.

Province of Oviedo.—At Covadonga, about 6 miles south-west of Cangas de Onis, a small town 35 miles E.N.E. of Oviedo, a group of mines is being exploited by the Asturiana Mines, Ltd. The ores produced are (*a*) manganese ore, (*b*) iron ore, and (*c*) manganiferous iron-ore. The deposits occur as a capping on limestone, the ore being covered to varying depths by an overburden of boulder clay. The ore is won either by opencast working after the removal of the clay, or by mining, the method depending on the thickness of the overburden. The product is washed, and the resulting minerals are passed over a picking-belt, the manganese ore and the iron ore being separated by hand. The remainder of the mineral, which is too small for hand-picking, is a mixture of pieces of iron ore and manganese ore, and is classed as "manganiferous ore." Statistics of production are not available.

Spanish Production and Exports of Manganese Ore.
(*Revista Minera Metalurgica y de Ingenieria*, Madrid.)

Year.	Production.	Exports.	
	Quantity (long tons).	Quantity (long tons).	Value* (£).
1913	21,247	27,346	61,146
1914	12,944	8,822	19,724
1915	14,098	8,989	20,100
1916	13,950	8,709	19,473
1917	56,550	21,280	47,581
1918	76,465	22,365	50,005
1919	65,614	17,853	39,919

The only production of manganiferous iron-ore in Spain during the period under review appears to have been about 50 long tons in 1917 and 98 long tons in 1918.

Sweden.

Manganese ores are at present mined chiefly at Späxeryd and Hohult, south of Jönköping, in the province of that name, and at Långban in Värmland; but they have also been worked at Bölet, north of Karlsborg, in the province of Skaraborg, and elsewhere in Sweden. The annual production of true manganese ore has never been large. Three types of manganese ores have been distinguished:—(1) pyrolusite with manganite, (2) hausmannite with braunite, and (3) carbonate of manganese accompanying iron ore. At Späxeryd the ore (chiefly pyrolusite) occurs in the

* Values converted to £ sterling at the rate of 25 pesetas = £1.

form of lodes in the granite; at Långban it consists of braunite and hausmannite, forming more or less irregular stratiform bodies in the dolomite.*

Production of Manganese Ore in Sweden.
(*Sveriges Officiella Statistik.* Annual.)

Year.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Quantity—long tons...	3,937	3,584	7,485	8,751	19,554	16,304	12,081
	£	£	£	£	£	£	£
Value†—total ...	8,869	7,712	17,834	38,442	60,952	108,802	96,783
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Value—per ton...	45 1	43 0	47 8	87 10	62 4	133 6	160 2

The annual production statistics do not show the average manganese and iron contents of the total ore mined; but it is stated that the production for the year 1916 included 3,166 long tons from Späxeryd, averaging 47 per cent. of manganese, and 706 long tons from Långban, averaging 56 per cent. The corresponding figures for 1917 were 6,043 long tons of ore containing 16 to 45 per cent. of manganese from Späxeryd, and 529 long tons averaging 56 per cent. of manganese from Långban.

Production of Powdered Pyrolusite in Sweden.
(*Sveriges Officiella Statistik.* Annual.)

Year.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Quantity—long tons...	72	79	124	151	152	77	120
	£	£	£	£	£	£	£
Value*—total ...	281	334	850	1,712	2,615	1,821	3,223
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Value—per ton...	78 0	84 7	137 1	226 9	344 1	472 11	537 2

Production of Manganese Alloys in Sweden.

The production of spiegeleisen in the blast-furnace was begun in Sweden in 1868. Since 1904 several alloys used chiefly in the steel industry have been manufactured by the electric-furnace method, these including silico-manganese containing from 20 to 30 per cent. of silicon and 70 to 50 per cent. of manganese.‡ Ferro-manganese production has been conducted on a considerably smaller scale than that of silico-manganese, and the former alloy has a limited application owing to its high silicon content.

* J. Guinchard, Historical and Statistical Handbook of Sweden, Stockholm, 1914, *1*, 49; *2*, 255.

† Values converted to £ sterling at the rate of 18·2 kronor = £1.

‡ J. Guinchard, *op. cit.*, *2*, 238, 305.

The production of the different manganese alloys in recent years has been as follows :—

(*Sveriges Officiella Statistik*, Stockholm. Annual.)

Year.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Ferro-manganese :							
Quantity—long tons	—	288	932	1,078	1,163	2,089	989
Silico-manganese :							
Quantity—long tons	1,353	1,283	2,291	3,145	4,297	2,028	1,535
Ferro - manganese - silicon-aluminium :							
Quantity—long tons	134	500	772	710	1,309	461	80

Imports of Ferro-silicon and Ferro-manganese into Sweden.

(*Statistik Årsbok*, Stockholm. Annual.)

The imports of these two alloys are not given separately in the official statistics. The combined imports thereof in recent years were as follows :—

Year.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Quantity—long tons	2,642	1,933	903	10	7	2·5	6·5
	£	£	£	£	£	£	£
Value*—total ...	14,752	8,137	8,091	49	504	277	259
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Value—per ton ...	111 8	84 2	179 2	98 0	1,440 0	2,216 0	796 11

The imports of these alloys in 1920 have been reported as 118 tons.† Imports of spiegeleisen in 1919 have been officially returned as 2,815 tons.

Exports of Ferro-silicon and Ferro-manganese from Sweden.

The combined exports of these two alloys in recent years were as follows :—

(*Statistik Årsbok*, Stockholm. Annual.)

Year.	1913.	1914.	1915.	1916.	1917.	1918.	1919.‡
Quantity—long tons	9,421	9,886	10,628	15,986	17,695	11,410	
	£	£	£	£	£	£	
Value*—total ...	107,855	121,668	186,582	442,996	611,290	424,743	
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	
Value—per ton ...	228 11	246 2	351 1	554 3	690 11	744 6	

* Values converted to £ sterling at the rate of 18·2 kronor = £1.

† *Stahl u. Eisen*, 10th February, 1921, 207.

‡ The exports of manganese alloys in 1919 have been officially returned as follows:—Ferro-manganese, 100 tons ; silico-manganese, 524 tons ; silico-alumino-manganese, 80 tons.

Tunis.

The principal manganese ore deposits of Tunis were stated in 1908* to occur inland not far from Aïn-Mularés, the amount of ore available being estimated at one million tons. The basis of this large estimate is not clear. In 1907 there was an output of 807 long tons, and in 1909 of 802 tons, but there appears to have been little, if any, subsequent production until 1915, when the mining of manganese ore was stimulated by the war. The deposit at Ghardimaou, near the Algerian frontier, where there is a limited reserve of ore containing from 35 to 40 per cent. of manganese was increasingly exploited, but the other manganiferous beds remained unworked.† The statistical information available is incomplete.

Production of Manganese Ore in Tunis.

(*Statistique de l'Industrie Minérale en France et en Algérie.* Annual.)

Year.	Quantity (long tons).	Value.‡	Value per ton.
		£	*s.* *d.*
1915	1,437	2,290	40 8
1916	1,994	4,055	40 8
1917	5,707	6,948	24 4
1918	1,378	—	—
1919	1,292	—	—

In 1918, 817 long tons of manganese ore, valued at £1,992, or 48*s.* 9*d.* per ton, were transported by the Tunisian railways. In the same year, 987 long tons of manganese ore, valued at 37*s.* 7*d.* per ton, were exported,§ of which 984 tons went to England, the small remainder going to France.

Costa Rica.

The manganese ore deposits of Costa Rica have been described by J. D. Sears.‖

Those hitherto discovered are all situated on the Nicoya Peninsula, in the province of Guanacaste, on the Pacific coast. They are found in several localities, but are either of low grade or of small extent. The only deposits from which ore was being shipped towards the end of the war were those at Playa Real.

* *Rassegna Mineraria, Metallurgica e Chimica*, Rome, 1908, *28*, 233–236.
† U.S. Comm. Rept. Supp., January 28, 1920.
‡ Values converted into sterling at the rate of 25 fr.=£1.
§ *L'Echo des Mines et de la Métallurgie*, Paris, 1919, 455–456.
‖ Deposits of Manganese Ore in Costa Rica and Panama: Bull. No. 710-C, U.S. Geol. Surv., 1919

Curiol and Lagarto, the first two being the only important producers. The ore-bodies are intimate mixtures of oxides of manganese, generally indistinguishable except by chemical analysis. The iron content is generally negligible, though at some places reaching a high percentage. The silica is usually mechanically mixed and not in chemical combination with the ore.

The manganese oxides are found mostly in small and irregular pockets or troughs along the contact between red metamorphic rocks (which probably owe their colour to hæmatite) and light-coloured sediments, the ore-bodies varying widely in thickness and quality. At a few places the troughs are of sufficient extent to be classed as sheets.

At Playa Real, on "70-metre hill," the deposit is about 500 feet in length and from 10 to 100 feet in width, and has an average thickness of about 5 feet.

At Curiol the ore-body, which is in direct contact with the igneous rock, is of different shape, standing almost vertical and having a width of about 20 feet and a depth, so far as explored, of more than 100 feet.

Owing to the irregularity of the troughs, variations in the thickness and quality of the deposits, and the numerous faults, it is difficult to determine available tonnage even where much work has been done; but it appears unlikely that large reserves of high-grade ore will be found to exist in most of the localities described. A number of the deposits show moderate quantities of low-grade ore, but they are at present of little value owing to the heavy cost of hauling to tide water. Ore running less than 40 to 45 per cent. of metallic manganese could not be profitably mined even at the high prices current during the war period. Moreover, even in the case of the higher-grade ore, only the most careful sorting and cobbing will usually keep the silica content low enough to make the ore acceptable by smelters.

As sorted by hand for shipment, the ore of the Playa Real mines now averages 50 per cent. of manganese and 10 per cent. of silica, iron being low and phosphorus practically absent. The proportion of manganese to oxygen is too high for a large percentage of pyrolusite. Most of the ore is hard.

The ore of the Curiol mine is notably pure from wall to wall, averaging without sorting over 50 per cent. of manganese with 10 per cent. of silica, and large blocks can be taken out which show only 1 or 2 per cent. of silica and over 55 per cent. of manganese (80 to 83 per cent. manganese dioxide). The ore is fairly hard.

Besides the deposits now producing and a few bodies near them which are to be exploited by the companies operating the mines at Playa Real and Curiol, only the deposits at Pavones, near the head of the Gulf of Nicoya, seem to offer any real hope of being worth development.

The mining of manganese ore in Costa Rica began in 1916, the first shipments being made in May of that year. The port of

shipment is about two miles south of Braxilito (Brazilito), considerably north of Punta Arenas, the chief port of Costa Rica on the Pacific side. Manganese-ore mining developed rapidly in the country in 1916 and 1917, and the industry was employing from 300 to 400 men in 1918.

Exports of Manganese Ore from Costa Rica.

Complete production and export statistics are not available, but practically the whole of the manganese ore exported from Costa Rica since production began in 1916 has been shipped to the United States, the quantities and values of the ore, as received in the latter country, being as follows :—

(U.S. Bureau of Foreign and Domestic Commerce, Department of Commerce.)

Year.	1916.	1917.	1918.	1919.
Quantity, long tons	1,244	7,163	9,680	9,988
Value, * total	£ 8,063	£ 44,084	£ 60,594	£ 73,174
Value per ton	*s. d.* 129 8	*s. d.* 123 1	*s. d.* 125 2	*s. d.* 146 6

Cuba.

Deposits of manganese ore occur in Cuba in the provinces of Oriente, Santa Clara, Matanzas and Pinar del Rio, most of the mines being on the south coast. All the known deposits have been described by E. F. Burchard,† who examined most of them early in 1918. The following general classes were recognized :—(*a*) deposits in bedded rocks; (*b*) deposits in irregular masses associated with siliceous rocks, such as jasper or "bayate"; and (*c*) deposits of nodules and fragments in residual clay. It is estimated that there are from 700,000 to 800,000 tons of ore containing more than 36 per cent. of manganese in the deposits examined, most of which are in the Santiago district, Eastern Cuba.

In Oriente province the deposits occur in three areas, one north and north-east of Santiago de Cuba; another south of Bayamo and Baire; and the third on the Caribbean coast, near Portillo. The first two include the only extensive deposits in Cuba, these giving promise of a considerable production. In Santa Clara province a little ore has been found near the Caribbean coast west of the seaport of Trinidad. In Pinar del

* Values converted to £ sterling at the rate of $1=4*s*. 2*d*.

† Manganese Ore Deposits in Cuba : Trans. Amer. Inst. Min. and Met. Eng., New York : Preliminary pamphlet, 1919.

Rio province small deposits occur north of the city of that name and farther west near Mendoza.*

The manganese ores of Cuba are of special importance to the United States because of the close proximity of the island to the eastern coast of the latter country. The ore exported to the United States comes chiefly from the province of Oriente, much of it having to be transported by road from three to fifteen miles to the nearest point of railway, between which and the shipping ports of Santiago and Nipe the distance is short.

Even at the high prices for manganese ore ruling during the war period, only a small number of the many mines in eastern Cuba could be operated at a profit, owing to lack of proper transportation facilities.

The principal groups of mines, in the order of their importance, are the Ponupo, the Cristo, and the Cauto. The first two groups are worked by Aguilera and Company, and the third group is exploited by the Cauto Mining Company, a Rogers-Brown (United States) interest at San Nicolas, north of Santiago.

The Ponupo group, which is near the railway, produces ore averaging 38 to 40 per cent. of manganese and rather low in silica and iron. The output of the Cristo group of claims runs slightly higher in manganese than that of the Ponupo group, and about the same in silica and iron, but the greater part of it requires washing. In 1914 the Cauto group was said to be mining ore containing 43 to 47 per cent. of manganese, 9 of silica, 2 of iron, and 0·05 of phosphorus, small lots (classed as "dioxide") being selected for shipment which contained from 85 to 87 per cent. of manganese dioxide. Modern machinery has been installed at the San Nicolas mines, which are expected to become increasingly productive. Ore of high grade is produced by the Palmarito and the Los Negros groups. Four other groups of mines in eastern Cuba are producing manganese ore on a small scale.†

Deposits of manganese ore near Cabagan, Santa Clara province, 40 miles west of Trinidad, on the south coast, were exploited by the Trinidad Manganese Company of Habana in 1916, and a first small shipment was made to the United States early in 1917.‡

J. B. Stewart§ states that 75 per cent. of the total Cuban output of manganese ore in 1918 was washed or concentrated, and that, outside of the province of Oriente, the production in that year was negligible.

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* Min. Ind., New York, 1918, *27*, 473.

† U.S. Commerce Rept., March 25, 1918, and D. F. Hewett, Manganese and Manganiferous Ores in 1914 : U.S. Geol. Surv. Min. Res. U.S., 181.

‡ D. F. Hewett, Manganese and Manganiferous Ores in 1916, U.S. Geol. Surv. Min. Res. U.S., 751.

§ Cuban Manganese in 1918 : Eng. & Min. Journ., New York, 1919, *107*, 196.

Production of Manganese Ore in Cuba.

There appears to have been no production of manganese ore in Cuba in 1913 or 1914. The figures for subsequent years are as follows :—

(Manganese and Manganiferous Ores : U.S. Geol. Surv., Min. Res. U.S. Annual.)

Year.	Quantity (long tons).
1915	9,000
1916	33,120
1917	44,496
1918	81,966
1919	17,711

Exports of Manganese Ore from Cuba to the United States.

The following table shows the quantities and values of the imports of manganese ore received by the United States from Cuba :—

(U.S. Bureau of Foreign and Domestic Commerce, Department of Commerce.)

Year.	1915.	1916.	1917.	1918.	1919.
Quantity, long tons ...	5,141	30,563	44,511	82,974	35,320
Value,* total	£ 14,469	£ 107,122	£ 127,586	£ 573,165	£ 298,584
„ per ton	*s. d.* 56 3·5	*s. d.* 70 1·2	*s. d.* 57 3·9	*s. d.* 138 1·9	*s. d.* 169 0·9

Cost of Manganese Ore Production in Cuba.

(C. M. Weld : *op. cit.*, 103-104.)

Manganese ore mining in Cuba is generally done by open-cut methods, and preparation for market by hand-cleaning. Before the war, royalties were usually $1 per ton, but these advanced materially during the war period. The cost figures for 1918 ranged as follows :—

	$	$
Mining and treatment	5.00 to	8.00
Hauling to railway (according to distance)	2.00 ,,	12.00
Cuban railway freight	1.00 ,,	2.50
Port costs and charges	0.75 ,,	1.50
Royalty	1.50 ,,	2.50

* Values converted to £ sterling at the rate of $1 = 4*s.* 2*d.*

As regards the bulk of their output, the two largest producers in Cuba were situated directly on the railway or on tram lines leading to it. This and other factors are taken into account in estimating the average cost f.o.b. steamer in 1918 at $14 per ton, including miscellaneous and general charges, but not amortization.

Ocean freight rates on Manganese Ores from Cuba.

The same authority (p. 105) gives the ocean freight rates on manganese ores from Cuba to the United States as follows :—

	Per long ton.
	$
Pre-war	1.50 to 2.50
1918	9.50

The figure for 1918, which is about five times the pre-war rate, is understood to include insurance.

The average rail freight during the war from the United States Atlantic seaboard to the consumer in that country is estimated to have been about $3 per long ton.

Assembling the foregoing figures, the total estimated average cost of Cuban manganese ore delivered at United States furnaces in 1918 was $23.50 per long ton. On a unit basis this would be 62 cents for ore containing 38 per cent. of manganese.

Before the war, such ore as was shipped from Cuba was of a higher grade than that mined during the war, and was sold at the United States Atlantic seaboard for $10 to $12 per ton, or, say, $8 to $10 per ton into ship at a Cuban port. It is considered unlikely that the cost of ore from Cuba will drop in the future from its present enhanced price much below $11 to $12 per ton, although it is certain that ocean freights will drop materially, not improbably to the pre-war figure.

On this assumption it is expected that Cuban ores will reach the United States Atlantic seaboard in the not remote future at a cost of about $13.50, or, say, $16.50 per ton delivered at the furnace if the United States rail freight is not reduced. The quality of the ore, to be saleable, will have to be better than it was during 1918. If it should contain an average of, say, 41 units of manganese, the estimated future cost delivered to the furnace becomes 40 cents. per unit. At an equal price, Brazilian ore will always have the preference over Cuban owing to its higher content of metallic manganese.

Mexico.

A group of mines at Concepcion Point, Lower California, was reported in 1916* to be exploiting what were described as the richest known deposits of manganese ore in the world. These deposits are situated in a peninsula, 25 miles in length and from 5 to 8 miles in width, between the Gulf of California and Concep-

* Article in the *Boletin Minero*, quoted in the Min. Journ., London, 1916, June 24, and the Min. Ind., New York, 1916, *25*, 497.

cion Bay. The Pilares de Gavilan mines consist of 15 claims, the outcropping veins being from 1 to 5 feet in thickness and estimated to contain nearly 1¾ million tons of pure manganese ore. The veins of the Trinidad mines vary in thickness from a few inches to 16 feet, and those of the Guadalupe mine from 5 to 6 feet.

In the same year, deposits of high-grade manganese ore were reported to occur near Candela, in the eastern part of Coahuila, a State lying between Chihuahua and Nuevo Leon.

A considerable amount of prospecting of manganese ore deposits was done in 1918 in the vicinity of the city of Chihuahua, and, in the latter part of that year, about 350 tons of ore containing from 40 to 48 per cent. of manganese were exported to the United States.* In the same year it was reported that manganese ore was being mined by Americans 4 miles north of Chihuahua, 15 miles south of Palomas, and 45 miles south-west of Chihuahua. Manganese ore deposits were also being exploited in a mountainous region 18 miles from Leon, in the State of Guanajuato.†

By Presidential decree, effective on April 28, 1918, a duty of 3 per cent. of the value on New York markets was placed on exports of manganese ore from Mexico.‡

Production of Manganese Ore in Mexico.

The production of manganese ore in Mexico during the period under review has been reported as follows :—

(Mexican Secretariat of Industry, Commerce and Labour.)

	Quantity (long tons).
1917	72
1918	2,832
1919	2,258

the production for 1920 being provisionally reported as 825 tons.

Exports of Manganese Ore from Mexico to the United States.

For the period under review, the imports of manganese ore from Mexico into the United States were as follows :—

(U.S. Bureau of Foreign and Domestic Commerce, Dept. of Commerce.)

Year.	1916.	1917.	1918.	1919.
Quantity, long tons ...	390	345	5,251	6,295
Value,§ total	£1,478	£2,040	£33,199	£55,856
Value per ton	75*s.* 10*d.*	118*s.* 3*d.*	126*s.* 5*d.*	177*s.* 5·5*d.*

* U.S. Daily Consular and Trade Reports, October 26, 1918.

† D. F. Hewett, Manganese and Manganiferous Ores in 1918 : U.S. Geol. Surv. Min. Res. U.S., p. 649.

‡ U.S. Daily Consular and Trade Reports, March 4, 1918.

§ Values converted to £ sterling at the rate of $1 = 4*s.* 2*d.*

Panama.

Deposits of manganese ore, principally in the form of irregular lenticular masses in decomposed shale, have been worked on the north side of the isthmus of Panama, in a region extending from Puerto Bello eastward for about 35 miles towards Mandinga on the Gulf of San Blas. In 1918, newly discovered deposits in the high country 12 to 15 miles south of Puerto Bello, on the Boqueron River, a branch of the Chagres River, attracted much attention.

There appears to have been no production of manganese ore in the Republic from 1901 until towards the end of 1915, when preparations were made for the re-opening of the Novedad and neighbouring mines at Nombre de Dios. In 1916 an American syndicate commenced shipping manganese ore to the United States from the Mandinga mines, about 20 miles east of those worked near Nombre de Dios. In 1918, the same syndicate obtained a concession to mine manganese ore from the deposits on the Boqueron River.

Two manganiferous deposits occurring on the west side of Boqueron River have been described by J. D. Sears.*

In the first of these localities the ore is a mixture of oxides of manganese, hard, black, and for the most part very pure. Where exposed it is segregated in lenses and sheets in clays of various colours, but is not in contact with any hard rock. Much of the ore seen is in the form of boulders. The manganese oxide is evidently of secondary origin, being the result of concentration and segregation in the residual clays formed by the weathering of the older rocks. The work done indicates that from 10,000 to 15,000 tons of manganese ore are without doubt easily available, and the depth to which the mineral extends is not yet known.

In the second locality, manganese ore occurs in a zone of boulders along a branch of Diablo River, and up the slope of a steep hill between two of its forks, some of the boulders lying on the surface and some being buried in clay. The south slope of the hill has been extensively stripped, and good ore found in a sheet, from 1 to 15 feet (averaging about 8 feet) in thickness, roughly following the surface, in contact with clays, but so far as seen not with hard rock. It is suggested that the ore passes as a connected sheet through the hill towards its summit. The ore in sight when the deposit was examined was estimated at 15,000 tons, most of the material being good and clean. An analysis made by the Panama Canal testing laboratory gave the following percentages on dry ore :—manganese, 55·3 (manganese dioxide, 84·00 and manganous oxide, 2·86); silica, 7·58;

* Deposits of manganese ore in Costa Rica and Panama ; Bull. No. 710-C, U.S. Geol. Surv., 1919.

phosphorus, 0·07; sulphur, 0·01; ferric oxide, 0·47; cuprous oxide, 0·88; with unimportant percentages of other objectionable constituents.

The Boqueron deposits have also been described by the British Consul at Colon,* who states that the boulders consist in almost every instance of solid ore, many weighing more than 150 tons. At the date of his report about 30,000 to 40,000 tons of surface ore were estimated to be in sight at the two mines already started, which with a little hand-sorting would average over 50 per cent of manganese. The properties cover an area of about 2,500 acres. The Boqueron River could furnish at least 2,000 h.p.; labour is cheap; and the fines could be concentrated at a very small cost. With the building of a small wharf at Nombre de Dios, about 8 miles from the deposits, it is estimated that steamers of 2,000 to 2,500 tons capacity could load cargo at that port, to which it is stated to be probable that a railway will be built.

Production of Manganese Ore in Panama.

Complete production and export statistics are not available, but practically all the ore produced in recent years was shipped to the United States, the quantities and values of the ore as received in that country being as follows:—

(U.S. Bureau of Foreign and Domestic Commerce, Dept. of Commerce.)

Year.	1916.	1917.	1918.	1919.
Quantity, long tons ...	10,498	5,202	5,607	2
Value,† total	£ 55,369	£ 33,983	£ 54,692	£ 16
Value per ton	s. d. 105 6	s. d. 130 8	s. d. 195 1	s. d. 160 0

Porto Rico.

Little information is available concerning deposits of manganese ore in the island of Porto Rico, a possession of the United States in the West Indies.

In 1916, the occurrence of high-grade manganese ore 6 miles from the village of Juana Diaz, which is about 10 miles E.N.E. of Ponce, was reported by the Commissioner of the Interior, Porto Rico.‡

* Bd. of Tr. Journ., London, 1919, *102*, 553.

† Values converted to £ sterling at the rate of $1 = 4*s*. 2*d*.

‡ D. F. Hewett, Manganese and Manganiferous Ores in 1916: U.S. Geol. Surv. Min. Res. U.S., p. 752.

Production of Manganese Ore in Porto Rico.

(U.S. Bureau of Foreign and Domestic Commerce, Dept. of Commerce.)

The following figures represent exports, all of which were to the United States :—

Year.	Quantity (long tons).
1916	737
1917	1,189
1918	1,350
1919	

The value of the ore is not separately given in the statistics available.

United States.

The annual production of true manganese ore in the United States prior to the war was almost negligible, having regard to the enormous requirements of the domestic iron and steel industry; but for a long series of years there has been a large production of manganiferous iron-ores, manganiferous zinc-ores, and manganiferous silver-ores.

Most of the known deposits of manganese ore proper are of small extent, discontinuous, and scattered; the ore is low in manganese and high in silica; and nearly all of it requires to be either washed or sorted, or both.*

During 1913, the United States produced only 4,048 long tons of ore containing 35 per cent. or more of manganese, all of this being obtained in the State of Virginia. The output fell to 2,635 long tons in 1914, only two-thirds of this small total being mined in Virginia. From that year until the end of the war the domestic production of manganese ore increased very rapidly, the known deposits being intensively exploited and new sources of supply sought for and developed, in order to cover the shortage of shipments from India and the entire cutting-off of Russian supplies. The domestic output of this class of ore reached its maximum in 1918, when 305,869 long tons were produced, of which 199,932 tons came from Montana. After the Armistice there was a sharp fall in the domestic production, which amounted to only 55,322 tons in 1919.† In 1920, however, the output was about 94,000 tons.

Increased quantities of manganiferous material were also obtained in the United States during the war period from the working of domestic manganiferous iron-, silver- and zinc-ores.

For the greater part of her abnormally large requirements, however, the United States was dependent during the war on

* E. C. Harder; Bull. No. 427, U.S. Geol. Surv., 1910, 14.

† H. A. C. Jenison, Manganese and Manganiferous Ores in 1919: U.S. Geol. Surv. Min. Res. U.S.

foreign sources of supply, and especially on Brazil, whose exports of manganese ore to the United States rose from 70,200 long tons in 1913 to 524,291 long tons in 1917. Of the other western countries contributing to the United States' imports of manganese ore during the war, the most important was Cuba, whose exports to America rose from 5,141 tons in 1915 to 82,974 tons in 1918. Shipments from British India, although very seriously curtailed, were in no year of the war period entirely cut off.

The last year of the hostilities showed that the known domestic deposits could supply about 32 per cent. of the true manganese ore requirements of the United States. At the end of 1918, the amount of ore in sight in these deposits containing 35 per cent. or more of manganese was only 699,750 tons, with 1,130,000 tons more in prospect.* Taking the normal consumption of such ore in the United States as 350,000 tons per annum, these reserves would be exhausted in from two to five years, if no foreign ore were imported. The actual production of steel in the United States during the last two years of the war (1917-1918) averaged about 45 million tons per annum (as against an average of about 31¼ million tons per annum for the years 1912-13),† the domestic consumption of manganese ore in each of these war years being about 850,000 tons. The cost of mining manganese ore in the United States is so much higher than the cost in foreign countries, and the grade of the domestic ore in general is so much lower than that of the foreign ore, that the domestic producers cannot readily compete with the foreign producers under the present tariff so long as shipping is available. Much of the domestic production of manganese ore during the war was made at an actual loss, in spite of the high prices current during the period.‡

In addition to the reserves of high-grade manganese ore in sight and in prospect, nearly 17½ million tons of low-grade material, containing from 5 to 35 per cent. of manganese, are estimated to be in sight in the known deposits of the United States, with 2,630,000 tons more in prospect.

The States contributing chiefly to the production of manganese ore during the period under review were, in the order of their productivity in the last year of the war: Montana, California, Nevada, Arizona, Virginia, Arkansas, Georgia, Utah, Colorado, Tennessee and New Mexico.

In addition to manganese ore, large quantities of manganiferous silver-ore were produced in certain of the States mentioned above, notably Colorado, Nevada and Arizona, minor quantities coming from New Mexico and Utah.

Large deposits of manganiferous iron-ores occur in the New England, Appalachian and Lake Superior regions, 90 per cent. or more of the output of such ores in the United States prior to

* U.S. Geol. Surv., Dec. 1918.
† American Iron and Steel Inst.
‡ The Mineral Industry, New York, 1919, 445.

the war having been obtained from the Lake Superior deposits. The output of that region contains 12 to 25 per cent. of manganese and is mainly used for the manufacture of spiegeleisen or, in admixture with high-grade imported manganese ore, for the production of ferro-manganese. Such part of the output as is too low in manganese for the making of ferro-alloys is used in blast-furnaces for the production of " high-manganese " pig-iron, this being also done with Appalachian ores of similar grade. This pig-iron, which has a manganese content ranging from 1·5 to 5 per cent., is largely used in the United States for the manufacture of railway car wheels.

During the war, the deposits of manganiferous iron-ore in the Cuyuna Range, Minnesota, yielded a greatly increased output, the production of ore containing 10 to 35 per cent. of manganese rising from 42,973 long tons in 1915 to 625,009 tons in 1918, while that of ore containing only 5 to 10 per cent. of manganese rose from 45,712 tons in 1916 to 227,202 tons in 1918.* The output in this region fell sharply on the conclusion of hostilities.

All the low-grade manganiferous ore shipped in Michigan in recent years was derived from the Bengal mine in Iron County. As shipped in 1917, this ore contained (on a dry basis) 16·83 per cent. of manganese, 37·01 per cent. of iron, and 5·48 per cent. of silica.

Less important deposits of ferruginous manganese-ore and manganiferous iron-ore occur in other regions, those of Colorado having yielded a considerable output.

The production of manganiferous residuum from zinc roasting in New Jersey rose from 102,239 long tons in 1913 to a maximum of 198,817 tons in 1916, but amounted to only 80,418 tons in 1919, the smallest output since 1905. The production of this material is dependent on the output of zinc ore.

H. D McCaskey and E. F. Burchard† remark that one direct result of the shortage of manganese ore in the United States during the war was to cause miners of manganiferous silver-ores to select portions of the ore rich enough in manganese to be more valuable for that metal than for their small gold and silver content. Thus, a mine in the Tombstone district, Arizona, treated a fairly large quantity of the raw ore in mills and produced a concentrate rich enough in manganese to be used in making dry cells and ferro-manganese, while the tailing was shipped to smelters as a flux. In the Philipsburg district, Montana, high-grade manganese ore was mined and shipped from the oxidized zones of gold and silver-bearing veins that had never before been sources of manganese ore. The Leadville district, Colorado, con-

* D. F. Hewett, Manganese and Manganiferous Ores: U.S. Geol. Surv. Min. Res. U.S. (Annual).

† Our Mineral Supplies: U.S. Geol. Surv., Bull. 666, 1919, 31.

tinued, as for many previous years, to produce manganiferous silver-ore containing 10 to 40 per cent. of manganese, 10 to 30 of iron, and 5 to 20 of silica, which is normally shipped either to the smelters for its silver value, or to steel works for its manganese value, as may be the more advantageous to the producer. In addition, the Pioche district, Nevada, became during the war a source of large shipments of manganiferous silver-ore, which was largely used as a flux by lead smelters.

Since shipments commenced in 1916, Montana has been the leading producer of true manganese ore in the United States, the most important district being Philipsburg, where, however, in common with most of the other manganese ore deposits of the State, the oxidized mineral contains a high percentage of free silica and other gangue, and is usually concentrated to make a marketable product. The district contains the largest deposits of readily available high-grade manganese ore in the United States. After the Armistice, the output of Montana fell sharply, but in 1920 amounted to about 76,440 tons.

It is estimated that over 5 million tons of manganese ore are contained in the Crimora deposit, Virginia.* During the period 1880-1914, the output of manganese ore in this State amounted to 61 per cent. of the total domestic production, nearly two-thirds of the Virginian output being reported to have come from the Crimora mines.† The ore occurs as pyrolusite and psilomelane, the average amount of manganese appearing to be slightly under 50 per cent., that of silica being rather high and sometimes excessive, the phosphorus percentage fairly low, and the content of iron from 2 up to (exceptionally) 4·5 per cent. The best quality contains 57·29 per cent. of manganese, 0·37 of iron, 2·13 of silica, and 0·075 of phosphorus.‡ During the war these mines were re-opened and a new plant was erected for mining, washing, and crushing the ores.

The important manganiferous iron-ore deposits of the Cuyuna district, Minnesota, have been exhaustively described by E. Newton.§ The main structural features of the district consist of a series of more or less parallel folds whose longer axes lie in a general N.E.—S.W. direction, the iron-bearing formation consisting of a great thickness of schists and schistose slates.

The manganiferous iron-ore bodies occur principally in a somewhat restricted portion of the so-called North Range, as parallel or over-lapping lenses, while some manganiferous ore has been found in a parallel belt known as the South Range. In general,

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* Iron Age, 1916, *97*, 776.
† D. F. Hewett: Bull. No. 640–C, U.S. Geol. Surv., 1916, 37.
‡ T. L. Watson: Min. Res. of Virginia, 1907, 248.
§ Manganiferous iron-ores of the Cuyuna district, Minnesota: Minn. School of Mines, Experiment Station, Bull. No. 5, 1918.

the direct shipping iron ores of the district carry only about 0·30 per cent. of manganese. In certain of the iron ore bodies of the North Range that have been opened up as iron mines, there are irregular pockets or lenses of material carrying from 1 per cent. up to 12 or 15 per cent. of manganese. These mines are situated along a belt beginning near the west end of the North Range and extending for a distance of about five miles in a north-easterly direction. North of this belt several ore-bodies are being worked almost exclusively for their manganese content; and, north of these, there is another series of manganiferous iron-ore bodies, some of which are being exploited solely for their manganese.

In general, the tonnage of the so-called " low phosphorus-high silica " deposits is smaller than that of the " high phosphorus-low silica " ore-bodies. The following figures are a summary of a table given by E. Newton (*op. cit.*, 10-11), stated to represent conservative estimates made of tonnages and grades existing in the known manganiferous deposits based on drilling and other data available :—

Grade and Tonnage.	Range of Composition, per cent.			
	Manganese.	Iron.	Silica.	Phosphorus.
Over 10 per cent. of manganese and under 0·1 of phosphorus— 7 deposits aggregating 1,442,000 long tons.	11·44 to 20·18.	27·45 to 43·87 (exceptionally 20·09).	17·00 to 18·70 (exceptionally 13·79 and 30·00).	0·031 to 0·093.
Over 10 per cent. of manganese and 0·10–0·20 of phosphorus— 8 deposits aggregating 1,404,000 long tons.	10·11 to 19·23.	29·41 to 43·93.	8·80 to 23·00.	0·120 to 0·198.
Over 10 per cent. of manganese and over 0·20 of phosphorus— 6 deposits aggregating 8,297,000 long tons.	10·20 to 13·00.	40·54 to 44·16 (exceptionally 35·00).	5·40 to 10·00 (exceptionally 19·00).	0·236 to 0·290 (exceptionally 0·353).
Under 10 per cent. of manganese— 9 deposits aggregating 4,265,000 long tons.	3·40 to 9·54	43·59 to 52·49.	10·00 to 11·53 (only two analyses given).	0·200 to 0·250 (exceptionally 0·125 and 0·300)

The following analyses represent run-of-mine ore that has been shipped without any preparation, it being understood that the term "low phosphorus," as applied to the manganiferous iron-ores of the Cuyuna Range, is merely relative and should not be considered as referring to ores of Bessemer grade.

(Samples dried at 100°C.)

	Analysis : Per cent.	
	High phosphorus ore.	Low phosphorus ore.
Iron	39·30	29·60
Phosphorus	0·170	0·075
Silica	8·54	16·85
Manganese	13·43	20·00
Alumina	3·50	1·50
Lime	0·35	0·35
Magnesia	0·50	0·60
Sulphur	0·015	—
Loss on ignition	10·00	6·60
Moisture	14·00	9·00

At the present time the high phosphorus ores are used to increase the manganese content of basic pig-iron, for this purpose being mixed with iron ore so as to constitute from 3 to 5 per cent. of the ore charged into the blast furnace. The so-called low phosphorus ores are used for making spiegeleisen. The serious shortage of ferro-manganese and high-grade manganese ore in the United States, late in 1917, created a larger market for spiegeleisen and low-grade manganiferous ore, with the result that shipments of Cuyuna Range manganiferous iron-ores in 1918 amounted to nearly twice those in 1917.

E. Newton (*op. cit.*) has summarized an exhaustive investigation of the possible methods of beneficiation (removal of silica, separation of iron from manganese minerals, and removal of phosphorus), so as to obtain a product better suited for metallurgical uses than the ore as mined.

Manganese Ore and Manganiferous Ore produced and marketed in the United States.

(Manganese and Manganiferous Ores: U.S. Geol. Surv. Min. Res. U.S. Annual.)

Year.	Ore containing								
	35 per cent. or more of Manganese.			10 to 35 per cent. of Manganese. ("Ferruginous manganese-ore.")			5 to 10 per cent. of Manganese. ("Manganiferous iron-ore.")		
	Long tons.	Average* value per ton.		Long tons.	Average* value per ton.		Long tons.	Average* value per ton.	
		£	s. d.		£	s. d.		£	s. d.
1913	4,048	2	1 8	51,512	0	2 0·5	7,891		†
1914	2,635	2	3 3·5	91,666	0	9 11	6,599‡		†
1915	9,613	2	9 0·5	180,953	0	18 4	14,782‡	0	5 8
1916	31,474	4	6 10·5	453,853	0	16 5	90,473‡	0	8 8·5
1917	129,405	6	12 4	730,759	0	17 3·5	130,185‡	0	11 10
1918	305,869	5	12 3	916,163§	1	0 11	254,299§	0	16 11
1919	55,322	6	15 4	309,834	0	15 11	123,899	0	12 5·3
1920‖	94,000	5	5 9	416,000	0	15 6	257,000	0	8 9

The production of manganese ore (35 per cent. or more of manganese) by States during the period under review is shown in the table below.

The leading producers of "ferruginous manganese-ore" (10 to 35 per cent. of manganese) in 1919 were Minnesota (138,952 tons, as against 630,827 tons in 1918), Nevada (84,040 tons, as against 80,354 tons), Colorado (29,494 tons as against 112,354 tons), and Michigan (29,296 tons, as against 22,673 tons). Next in order of importance followed New Mexico, Virginia and Georgia, with quantities ranging from 12,198 tons down to 3,496 tons, minor quantities being reported from other States. As in former years, nearly all the manganiferous ore mined in Nevada was sold to smelters for use in fluxing.

As in previous years, most of the "manganiferous iron-ore" (5 to 10 per cent. manganese) marketed in 1919 and 1920 was

* Values converted to £ sterling at the rate of $1 = 4s. 2d.

† Value of ore containing 5 to 10 per cent of manganese included in figures for ore containing 10 to 35 per cent., the figures not being separable.

‡ Includes a small proportion of ore containing less than 5 per cent. of manganese.

§ Fluxing ore from Colorado not included, as figures not yet available

‖ U.S. Geol. Surv., May 10, 1921. Preliminary figures.

produced in Minnesota, whose output in 1919 was 106,931 tons, as against 229,869 tons in 1918. In addition, 115,983 tons of manganiferous iron-ore, containing approximately 5 per cent. of manganese, was shipped from Wisconsin in 1919, but, for an unexplained reason this is "not included in totals for the United States."

Production of Manganese Ore (35 per cent. or more of manganese) in the United States, by States.

(The figures represent ore marketed, or "shipments.")

(Manganese and Manganiferous Ores: U.S. Geol. Surv. Min. Res. U.S. Annual.)

State.	Quantity (long tons).						
	1913	1914	1915	1916	1917	1918	1919.
Alabama	—	—	200	‡	264	709	40
Arizona	—	—	339	3,060	14,802	17,612	547
Arkansas ...	—	—	1,288	6,318	10,140	7,731	2,558
California ...	—	501	2,563	6,136	14,196	24,067	11,289
Colorado	—	—	150	110	114	4,821	11,166
Georgia	—	—	3,168	‡	3,614	6,679	48
Montana	—	—	—	6,418	61,109	199,932	24,993
Nevada	—	—	—	‡	3,450	19,872	425
New Jersey ...	—	—	—	—	—	64	—
New Mexico ...	—	—	—	‡	2,603	3,126	—
North Carolina ...	—	—	—	—	102	315	—
Oregon	—	—	—	—	—	198	—
South Carolina ...	—	—	—	—	405	100	—
South Dakota ...	—	—	—	—	—	31	—
Tennessee ...	—	—	150	429	1,996	4,162	328
Texas	—	—	‡	‡	25	380	—
Utah	—	—	55	1,282	4,195	5,100	—
Virginia	4,048†	1,724	1,620	4,417	12,360	10,928	3,928
Wyoming ...	—	—	—	—	30	42	—
Undistributed ...	—	410	80	3,304	—	—	—
Total (tons)	4,048†	2,635	9,613	31,474	129,405	305,869	55,322
Total Value*	£ 8,433	£ 5,704	£ 23,565	£ 136,725	£ 856,192	£ 1,716,747	£ 374,346
Average value per ton ...	*s. d.* 41 8	*s. d.* 43 3·5	*s. d.* 49 0·5	*s. d.* 86 10·5	*s. d.* 132 4	*s. d.* 112 3	*s. d.* 135 4

The production for 1920 has been estimated at approximately 94,000 tons, of which about 76,440 tons was mined in Montana.

* Values converted to £ sterling at the rate of $1 = 4*s.* 2*d.*

† Includes small quantity produced in 1911 and 1912, but not reported for those years.

‡ Included under "Undistributed."

Manganiferous Iron-ore marketed from the Cuyuna District, Minnesota, United States.

(Mineral Resources of the U.S. in 1919 : U.S. Geol. Surv.)

Year.	Ore containing 10 to 35 per cent. of Manganese. Quantity (long tons).	Ore containing 5 to 10 per cent. of Manganese. Quantity (long tons).
1913	26,200	—
1914	55,192	—
1915	42,973	—
1916	193,257	45,712
1917	359,542	91,590
1918	625,009	227,202
1919	138,952	98,220

Manganiferous Silver-ore marketed from mines in the United States.

(Mineral Resources of the U.S. in 1919 : U.S. Geol. Surv.)

Year.	Quantity (long tons).				
	Arizona.*	Colorado.†	Nevada.	New Mexico.	Utah.
1913 ...	—	49,753	—	—	—
1914 ...	—	39,881	—	—	—
1915 ...	1,452	30,921	104,498	—	55
1916 ...	7,392	106,863	122,429	—	27
1917 ...	32,009	124,715	122,872	—	100
1918 ...	10,854	124,041	80,096	475	—
1919 ...	1,964	40,824	77,815	250	—
1920 ...	345	45,717	95,142	541	—

* Ore containing more than 35 per cent. of manganese, sent to makers of manganese alloys, not included.
† Includes ore for fluxing.
‡ U.S. Geol. Surv., May 10, 1921.

Manganiferous Residuum produced from Zinc Roasting in New Jersey, United States.

Manganiferous zinc residuum contains from 12 to 15 per cent. of manganese and about 40 per cent. of iron. Since 1870 spiegeleisen has been manufactured in the United States from this residuum, but there is no record of the tonnage of such raw material used prior to 1889. During the period 1889-1912, the total production of manganiferous residuum from zinc roasting

in the United States was 1,688,319 long tons, the highest production for any year of that period being 141,264 long tons in 1909. The production since 1912 has been as follows :—

(Mineral Resources of the U.S. in 1919 : U.S. Geol. Surv.)

Year.	Quantity (long tons).
1913	102,239
1914	100,198
1915	159,318
1916	198,817
1917	155,332
1918	146,796
1919	80,418

Quantities of Manganese Ore Imported into the United States.

(U.S. Bureau of Foreign and Domestic Commerce, Dept. of Commerce.)

From	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Argentina ...	—	—	—	—	6,600	849	2,305
Anstralia ...	—	—	—	488	—	198	548
Belgium ...	—	450	—	—	—	—	—
Brazil ...	70,200	113,924	275,579	471,837	512,517	345,877	246,592
British India	141,587	103,583	36,450	51,960	48,975	29,275	9,200
Canada ...	5	64	325	756	883	301	582
Chile ...	—	—	—	—	202	2,997	441
Costa Rica...	—	—	—	1,244	7,163	9,680	9,988
Cuba ...	—	—	5,141	30,563	44,511	82,974	35,320
France ...	1,114	5	—	—	—	—	—
Germany ...	2,014	1,713	258	—	—	—	—
Greece ...	—	—	—	3,000	—	—	—
Japan ...	3	40	2,810	5,196	2,745	709	651
Mexico ...	—	—	—	390	345	5,251	6,295
Netherlands	—	2,505	50	—	—	—	-
Panama ...	—	—	—	10,498	5,202	5,607	2
Portugal ...	—	—	—	289	—	—	400
Russia ...	124,337	52,681	—	—	—	—	6,916
United Kingdom	227	8,321	49	100	805	4,362	9,470
Other Countries	5,603	8	116	—	24*	3,222†	4,634‡
Total ...	345,090	283,294	320,778	576,321	629,972	491,302	333,344

The quantity of manganese ore imported into the United States in 1920 was 606,937 tons, value £2,548,109. §

* Includes 4 tons from British South Africa and 20 tons from China.

† Includes 95 tons from British South Africa ; 107 tons from Ecuador ; 20 tons from Peru, and 3,000 tons from China.

‡ Includes 1,194 tons from British West Africa and 144 tons from British South Africa ; 2,000 tons from Turkey ; 20 tons from Ecuador ; 10 tons from Colombia ; 1 ton from China, and 1,265 tons from Hong Kong.

§ U.S. Geol. Surv., May 10, 1921.

Values of Manganese Ore Imported into the United States.

(U.S. Bureau of Foreign and Domestic Commerce, Dept. of Commerce.)

From	Value £ *						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Argentina... ...	—	—	—	—	8,338	8,152	18,031
Australia	—	—	—	4,024	—	2,915	5,493
Belgium	—	1,232	—	—	—	—	—
Brazil	92,850	153,494	466,841	1,487,463	1,787,145	2,119,612	1,495,223
British India ...	147,922	105,204	40,547	83,704	75,538	114,143	53,119
Canada	131	283	2,706	15,103	8,444	2,493	3,527
Chile	—	—	—	4	1,319	10,158	2,906
Costa Rica ...	—	—	—	8,063	44,084	60,594	73,173
Cuba	—	—	14,469	107,122	127,586	573,165	298,584
France	2,620	329	—	—	—	—	—
Germany	21,586	19,224	4,915	3	—	—	—
Greece	—	—	—	5,066	—	—	—
Japan	16	275	22,174	34,061	17,820	6,320	8,133
Mexico	—	—	—	1,478	2,040	33,199	55,480
Netherlands ...	—	10,878	373	—	—	—	—
Panama	—	—	—	55,369	33,983	54,692	16
Portugal	—	—	—	2,499	—	—	6,479
Russia	148,401	102,152	—	—	—	—	61,857
United Kingdom...	2,517	28,376	985	1,495	31,684	127,633	222,238
Other Countries ...	6,807	245	319	—	129†	31,896‡	35,154§
Total	422,850	421,692	553,329	1,805,454	2,138,110	3,144,972	2,339,413

* Values converted to £ sterling at the rate of $1=4s. 2d.

† Includes £38, British South Africa, and £91, China.

‡ Includes £443, British South Africa; £713, Ecuador; £134, Peru; and £30,606, China.

§ Includes £3,247, British West Africa, and £744, British South Africa; £25,000, Turkey; £134, Ecuador; £202, Colombia; £6, China; and £5,821, Hong Kong.

Manganese Alloys Imported into, and made from Domestic and Imported Ores in, the United States.

The combined production of ferro-manganese and spiegeleisen in the United States for the period 1872-1912 amounted to 5,069,213 long tons. During the ten years 1903-1912, immediately preceding the period under review, the domestic production of ferro-manganese was 765,033 long tons, and that of spiegeleisen 2,089,343 long tons, while 715,118 long tons of the former and 403,225 long tons of the latter alloy were imported from Europe. The ratios of the domestic production to the imports during the ten years were thus 1 :0·935 for ferro-manganese and 1 :0·193 for spiegeleisen. For 1913 the corresponding ratios were 1 :0·933 and 1 :0·0007, respectively, the importation of spiegeleisen having nearly ceased.

As will be seen from the table below, the production of both ferro-manganese and spiegeleisen in the United States increased greatly under the stress of the war, the imports of the

former alloy in 1918 being less than one-twelfth of the domestic production, while those of spiegeleisen were practically negligible.

(Manganese and Manganiferous Ores : U.S. Geol. Surv. Min. Res., U.S. Annual. [Production of Steel according to Amer. Iron and Steel Inst.].)

Alloy.	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Ferro-manganese : Imported	128,070	82,997	55,263	90,928	41,969	27,168	33,022
Domestic Production : From Domestic ore†	1,075	1,978	1,946	17,172	29,183	80,308	—
From Imported ore†	118,420	98,753	143,896	210,629	230,457	238,640	—
Total Domestic Production.*	119,495	100,731	145,842	227,801	260,270	318,948	185,357‡
Total ...	247,565	183,728	201,105	318,729	302,239	346,116	218,379
Spiegeleisen : Imported	77	2,870	200	—	3,968	1,969	27
Domestic Production : From Domestic ore	41,744	51,511	107,062	141,795	170,914	232,986	—
From Imported ore	65,236	25,114	7,384	43,027	28,110	40,966	—
Total Domestic Production.*	106,980	76,625	114,446	184,822	199,024	273,952	84,246‡
Total ...	107,057	79,495	114,646	184,822	202,992	275,921	84,273
TOTAL ...	354,622	263,223	315,751	503,551	505,231	622,037	302,652
Total Production of Steel in the United States.	31,300,874	23,513,030	32,151,036	42,773,680	45,060,607	44,462,432	34,671,232

* Total quantity made. † Partly estimated.
‡ Figures of production according to Amer. Iron and Steel Inst. (Figures showing quantity actually marketed not yet available.)

The production of ferro-manganese in the United States in 1920 has been reported as 295,447 tons, and that of spiegeleisen as 119,449 tons§ In the same year, 59,254 tons of ferro-manganese and 5,234 tons of spiegeleisen were imported.¶

[Min. Res. U.S. in 1919 (April 6, 1921), gives the total domestic production of ferro-manganese for years 1915 to 1918 inclusive as 144,260 tons, 224,103 tons, 260,225 tons, and 306,076 tons, respectively; and the total domestic production of spiegeleisen for the same years as 114,556 tons, 182,837 tons, 189,241 tons, and 263,861 tons, respectively; but does not state the quantities of either alloy produced from domestic and imported ores, respectively.]

§ Amer. Iron and Steel Inst. The total production of steel in United States for 1920 is given by this authority as 40,773,000 tons (approx.).
¶ U.S Geol. Surv., May 10, 1921.

Ferro-manganese Exported from the United States.

Year.	Quantity (long tons).	Value.*	
		Total.	Per ton.
		£	£ s. d.
1917 (July—December)	2,400	103,834	43 5 3
1918	3,577	167,935	46 18 11·5
1919	2,999	92,883	30 19 5
1920	3,454	—	—

* Values converted to £ sterling at the rate of $1 = 4s. 2d.

Average prices of Ferro-manganese and Spiegeleisen per gross ton, at Baltimore, U.S.A.

(Iron Trade Review, Cleveland, Ohio.)

Year.	Ferro-manganese.*		Spiegeleisen.†	
	High.‡	Low.‡	High.‡	Low.‡
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1913	13 11 2	10 18 4	—	—
1914	14 19 0·5	8 4 3	—	—
1915	22 12 3·5	17 2 10·5	5 16 8	5 16 2
1916	65 0 0	28 5 4·5	13 13 9	9 9 10·5
1917	71 0 8	58 6 6	15 14 5	13 15 1·5
1918	59 3 4	52 1 8	5 10 6·5	12 18 4
1919	44 5 5‖	21 17 6§	14 1 3‖	5 14 7¶

Argentina.

B. L. Miller and J. T. Singewald, Jr.,** mention a small deposit of manganese ore at Piedra Parada Grande, near San Luis, from which a shipment of 100 tons had been made. Other deposits are reported in the vicinity. They are apparently superficial deposits on gneiss, and the ore is mixed with quartz and other gangue substances.

According to a recent U.S. Commerce Report, †† there are now two mines producing manganese ore in Argentina, to supply the

* Prices of ferro-manganese from May, 1918, to January, 1919, inclusive, were based on 70 per cent. ferro-manganese, all other prices on 80 per cent. ferro-manganese.

† Prices of spiegeleisen from April, 1918, to June, 1919, inclusive, were based on 16 per cent. spiegeleisen, all other prices on 20 per cent. spiegeleisen.

‡ Prices converted to £ sterling at the rate of $1 = 4s. 2d.

‖ January, 1919.

§ September, 1919, thereafter to end of year, £22 18s. 4d. to £25 10s. 5d.

¶ June, 1919, thereafter to end of year, £7 1s. 8d. to £7 5s. 10d.

** *Op. cit.*, 1919, 49.

†† No. 19, January 24, 1921.

demands of the domestic glass and iron industries. Both of these mines are situated in the heart of the Santiago desert, one in the province of Cordoba, 75 miles north of Dean Funes, and the other 25 miles farther north, near Ojo de Agua, in the province of Santiago del Estero The ore occurs as manganese dioxide in a fissure in the granite hills known to extend for at least 50 miles. The deposit varies in width from 3 to 5 feet, but pinches to almost nothing at a depth of 40 or 50 feet. At the mine in Cordoba the ore has averaged from 65 to 68 per cent. manganese dioxide and 4 per cent. iron oxide, while samples from the Ojo de Agua mine show 75 per cent. manganese dioxide and only one-half of 1 per cent. iron oxide. The small surface deposit discovered earlier in the province of San Luis, about 250 miles to the south, is now thought to be another appearance of the same seam. Native labour costs only from 1s. to 2s. per day of 8 hours. With improved transport conditions, it is expected that the two mines will soon be producing a minimum of 600 tons of graded ore per month, of which one-half will be available for export.

Production statistics are not available for the period under review, but it would appear that no manganese ore was exported from Argentina during the years 1913-16. In subsequent years, the imports of such ore into the United States were as follows :—

Imports of Manganese Ore from Argentina into the United States.

(U.S. Bureau of Foreign and Domestic Commerce, Dept. of Commerce.)

Year.	Quantity (long tons).	Value* (£).
1917	6,600	8,358
1918	849	8,151
1919	2,305	18,031
1920	5,500	57,292

Brazil.

Before the war, Brazil ranked as the third important manganese ore producing country. During the early years of the war, the steel industry of North America was almost entirely dependent on Brazil for such ore, and this gave a great stimulus to the manganese mining industry of that country. It is considered likely that the United States will continue to look to Brazil for a large part of its future supplies of manganese ore, although, in order to obtain suitable mixtures for various metallurgical uses, considerable quantities will be required from other foreign countries. It is understood that the quality of the Brazilian ore exported to the United States towards the end of the war was appreciably lower than in its earlier years, the grade of ore from

* Values converted to £ sterling at the rate of $1 = 4s. 2d.

the principal mine falling from 48 or 50 to 45 per cent. or less of manganese.

Owing mainly to the fact that coal has not been found in any considerable quantity near the deposits of manganese ore or the still larger deposits of iron ore (estimated at more than 3,000 million tons, carrying 50 per cent. of iron, in Minas Geraes alone*), it has hitherto been necessary to export both of these ores instead of smelting them locally.

The first shipments of manganese ore from Brazil were made in 1894, from which year to the end of 1913 the total production amounted to nearly 2,600,000 long tons. The deposits of Minas Geraes, which persist to a depth of about 400 feet, have probably yielded more than 95 per cent. of the manganese ore hitherto exported. Small quantities have been shipped from the State of Bahia. The exploitation on a commercial scale of the extensive deposits in the State of Matto Grosso has been prevented by their great distance from the coast. Manganese ores occur also in the States of Maranhão, Paraná, Pernambuco, Rio de Janeiro, Rio Grande do Norte, Santa Catharina and São Paulo, but none of these deposits appears to have been actively mined.

The principal deposits have been described by E. C. Harder,† and those of the Lafayette (or Queluz) district, Minas Geraes, by J. T. Singewald, Jr., and B. L. Miller.‡

Minas Geraes.—The manganese ores of this State occur chiefly near the stations of Lafayette and Miguel Burnier, 283 miles and 311 miles respectively north of Rio de Janeiro on the Central of Brazil railway, some deposits occurring also along the branch railway from Miguel Burnier eastward to Ouro Preto. In 1911 the railway freight was 5 milreis (equivalent at that date to about 6s. 10·5d.) per metric ton for distances not exceeding 500 kilometres (311 miles), and for distances in excess of that limit 10 reis per ton-kilometre, equivalent to about 0·27d. per ton-mile.§

Mining was begun a little to the east of Miguel Burnier in 1894, the famous Wigg mine being started. During 1896-97 many deposits were discovered in the Lafayette (or Queluz) district, of which the Morro da Mina, north of Lafayette, on which mining commenced in 1904, has proved to be by far the most important. The combined reserves of the Wigg and the Morro da Mina mines were estimated at about 7 million tons in 1905,‖ and in 1915 it was estimated by the management of the

* General Economic and Financial Conditions of Brazil for the year 1919 : British Dept. of Overseas Trade, London, 1920, 25.

† Manganese Ores of Russia, India, Brazil and Chile : Trans. Amer. Inst. M.E., New York, 1916, *56*, 31–68.

‡ Manganese Ores of the Lafayette district, Minas Geraes, Brazil : Trans. Amer. Inst. M.E., 1916, *56*, 7–30 ; and Mineral Deposits of South America, 1919, 177–192.

§ D. Rocha : Cost of Transporting Manganese Ore in Brazil : Eng. Min. Journ., 1911, *91*, 553.

‖ Min. Res. U.S., 1905, 99.

Morro da Mina that development work had proved an ore reserve of 10 million tons in that mine alone* although it had already yielded about one million tons. The production of the mine at that date was at the rate of about 200,000 tons per annum.

Several smaller mines produce manganese ore intermittently, among these being the Rodeio, east of Miguel Burnier; the Cocuruto, south-west of Lafayette; and the Queluz das Minas, near the Morro da Mina mine. Inactive mines in this vicinity include the Piquery and the São Gonçalo, in the Lafayette district.

The manganese ore deposits in the region around Lafayette occur in a complex of granite, gneiss and crystalline schist, while those in the neighbourhood of Miguel Burnier and Ouro Preto occur in overlying metamorphosed sediments, with which the important Brazilian iron ores are associated.

Manganese ores are found scattered through the crystalline complex as large irregular bodies of manganese oxide (usually somewhat elongated and suggesting lenses), most of the bodies appearing to have either gneiss or crystalline schist on one or both bounding walls. Individual masses, as at Morro da Mina, may be several hundred yards in larger diameter.† The ore composing these lenses occurs mainly as massive drusy psilomelane, with some manganite and pyrolusite.

Average composition of Morro da Mina Ore as shipped.‡

(Ore dried at 100°C.)

	Per cent.	
Manganese	50·47	
Ferric oxide and alumina ...	8·75	(alumina about twice ferric oxide content).
Silica	1·76	
Phosphorus	0·069	
Insoluble residue	3·46	
Volatile matter	12·40	
Water	2·50	

Average analyses of Ore as shipped from other mines in the Lafayette District.§

(Ore dried at 100°C.)

	Piquery Mine. Per cent.	São Gonçalo Mine. Per cent.
Manganese	49·00 to 51·00	50·00 to 52·00
Silica	5·00 to 7·00	1·00 to 2·00
Phosphorus	0·08 to 0·10	0·12 to 0·15
Moisture	3·00 to 5·00	3·00 to 5·00

* Singewald and Miller: Trans. Amer. Inst. M.E., 1916, *56*, 15.
† E. C. Harder: *loc. cit.*, 58—59.
‡ Singewald and Miller: Trans. Amer. Inst. M.E., 1916, *56*, 16.
§ Min. Res. U.S., 1901, 142.

The manganese ore deposits in the sedimentary series occur as definite beds associated with ironstone. The principal bed, that on which the Wigg mine is situated, is from 2 to 3 miles in length, and has a maximum thickness of over 6 feet. This bed is bounded on one side by soft siliceous ironstone, with a contact zone of mixed soft crystalline hæmatite and manganese oxide, and on the other side by a ferruginous schist associated with the ironstone. The manganese deposit at the Rodeio mine is of smaller longitudinal extent but of greater thickness than that at the Wigg mine. The manganese ores associated with the sedimentary rocks consist of finely crystalline or amorphous manganese oxides, probably largely a mixture of pyrolusite and psilomelane, and are of somewhat better grade than those occurring in the crystalline complex.*

Typical Analyses of Wigg Mine Ores.

(Ore dried at 100° C.)

	Average. Per cent. (†)	Cargo. Per cent. (‡)
Manganese ...	50·00 to 54·00	54·14 to 55·02
Silica	1·00 to 2·00	0·53 to 1·25
Phosphorus ...	0·01 to 0·03	0·03 to 0·021
Moisture ...	15·00 to 20·00	4·95 to 4·74

Bahia.—The manganese ore deposits of this State are stated to be superficial, small, and very irregular. The more important occurrences are situated about 16 miles west of Nazareth, a town on the Jaguaripe river (navigable by vessels of light draught) about 30 miles south-west of the shipping port, Bahia. Three mines have been worked in the district, namely, the Sapé, Onha and Pedras Pretas; but for several years until 1917 these were idle. The deposits where mining has been carried on are estimated to contain more than 700,000 tons of ore.§ The Sapé and Onha mines are connected with the Nazareth railway by a narrow-gauge line, 5¼ miles in length. The Pedras Pretas mine is only about ½ mile from the main line, to which the ore is run down a gravity incline. At Nazareth the ore is put on sailing lighters and carried out to steamers. The cost of the ore on board ship, including mining and transportation, was given as 11*s.* 8*d.* per ton at about the end of 1916.‖

The region is hilly and heavily forested. The manganese ores occur in material derived by the decomposition of crystalline

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* E. C. Harder: *loc. cit.*, 60—61.
† Min. Res. U.S., 1901, 142.
‡ H. K. Scott; The Manganese Ores of Brazil: Journ. Iron and Steel Inst London, 1900, No. 1, 205.
§ Miller and Singewald: Min. Deposits of South America, 1919, 188.
‖ E. C. Harder: *loc. cit.*, 61—62.

schists probably belonging to the pre-Cambrian crystalline complex so extensively developed in eastern Brazil. The ore is mainly psilomelane, occurring as lumps and large masses (sometimes botryoidal but mostly angular) in clay and soft earth. At the Pedras Pretas mine, which has been the principal producer in the district, many of the lumps of ore are more than 2 feet in diameter, and masses weighing as much as 1½ ton are not uncommon, the smallest pieces shipped being about the size of a fist.*

Average Analysis of Ore from the Pedras Pretas Mine.

(D. F. Hewett: U.S. Geol. Surv. Min. Res. U.S., 1914, 181.)

	Per cent.
Manganese	43 to 49
Iron	3 to 6
Silica	3 to 4
Phosphorus	0·016
Moisture	2 to 3

Important mining operations were commenced in the State of Bahia in 1917, these including the exploitation of manganese ore deposits in the Bom-Fim district over 200 miles north-west of the port of Bahia. Manganese ore was mined in the State in that year by three companies. One of these, which controls several deposits in the interior and a mine on the coast, introduced machinery, with the intention of competing after the war. In 1918, however, mining in the interior had to be discontinued, owing to the inability of the railway to handle the output, 40,500 tons awaiting transportation. The deposit on the coast was being worked to its full capacity in that year.†

Matto Grosso.—The principal deposits of manganese ore in this State occur on the west side of the Paraguay river in two mountains, the Morro de Urucum and the Morro Grande, about 2 miles south-east of the village of Urucum, and a few miles south of Corumbá. The Morro de Urucum is an isolated, nearly flat-topped, hill rising about 2,600 feet above the surrounding comparatively level country. About half way up, two almost horizontal beds of manganese ore outcrop in strata consisting of banded ferruginous slates. The strata of Morro Grande are similar to those of Urucum, but only one bed of manganese ore is exposed. In three adits driven into the Urucum for short distances on different sides of the hill the ore beds averaged about 6½ feet, 7¼ feet and 10 feet respectively in thickness. The ores are firm and hard, varying in colour from brown to black. The manganese content of fifteen samples taken from the three

* J. C. Branner: The Manganese Deposits of Bahia and Minas, Brazil; Trans. Amer. Inst. M.E., 1899, *29*, 756—770.

† U.S. Daily Cons. and Trade Repts., May 23, 1918.

adits in 1913 ranged from 40·24 per cent. to 47·10 per cent., the average composition shown by analyses being as follows :—

	Per cent.		Per cent.
Manganese	44·03	Lime	0·230
Iron	13·83	Magnesia	trace
Silica	1·74	Titanium	trace
Phosphorus	0·200	Copper	0·006
Sulphur	0·015	Moisture	2·84
Alumina	2·30		

It was estimated at that date that about 250,000 tons of manganiferous ore were in sight in the Urucum mountain, and that, if the two beds extended continuously through the entire mountain, the total ore must amount to 15 million tons.*

It has recently been estimated that there are about 120 million tons of high-grade manganese ore in the State of Matto Grosso, with an average content of 45·6 per cent. manganese, the content being in some cases as high as 58 to 59 per cent. The deposits in the Morro de Urucum and Morro Grande are worked by a Brazilian mining and shipping company with headquarters in Rio de Janeiro, which has been granted concessionary rights for 70 years, dating from 1918, over an area of 25,000 acres. The company is being financed largely by British and American capitalists. According to a *Times* correspondent, about 10,000 tons of ore has been mined, and this is being held pending the completion of the new railway to the river port of Ladavio, near Corumbá. When plans have matured, the company hopes to produce up to 150,000 tons of ore per annum.†

Maranhão.—Important deposits of manganese ore were discovered during the war in the north-western corner of this State, in the municipality of Tury-assú, on the north coast of Brazil, about 190 miles east of Para. The deposits lie within a tract of 20,000 acres, the best outcrop of ore being 4½ miles from the harbour of São José, on the Piracaua river. Lighters of 300 tons capacity can come within a mile of these deposits, which have so far been explored by trenches only. Manganese oxides appear to form distinct lodes, ranging in width from 4 feet to nearly 9 feet, traceable for more than 3,000 feet. It is estimated that one hill contains about 300,000 tons of ore, carrying more than 48 per cent. of manganese, within 50 feet of the surface. Samples show 47·9 to 51·2 per cent. of manganese; 6·5 to 9·3 of iron; 4 to 5·1 of silica; and 0·04 to 0·20 of phosphorus.‡

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* Miller and Singewald: *op. cit.*, 1919, 190—191. (Description based on unpublished report by W. L. Cumings, who visited the region in 1913.)

† The Chemical Age, 1920, *2*, 533; Eng. and Min. Journ., New York, 1920, *110*, 673.

‡ U.S. Daily Cons. and Trade Repts., Feb. 8, 1918.

Production of Manganese Ore in Brazil.

From the beginning of production in 1894 to the end of 1912, the exports of manganese ore from Brazil amounted to nearly 2,400,000 long tons, the highest output in any one year being nearly 250,000 tons in 1910. The production during the period under review is indicated by the export statistics tabulated below, only an insignificant tonnage being retained for consumption in Brazil. The maximum production was reached in 1917, the output for 1918 showing a great falling off, due to the large production in the United States. According to the *Mineral Industry* (1919, *28*, 452), the high taxes of the Brazilian Government caused the United States Steel Corporation to turn to other sources for ore at the close of the war; and, at about the middle of 1920, about 300,000 tons of ore was lying at Rio Janeiro unshipped, cheaper material being available. During 1920, however, 421,523 tons reached the United States from Brazil.

Exports of Manganese Ore from Brazil.

(*Commercio Exterior do Brasil* and other sources.)

Exported to	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom ...	18,792*	46,494*	9,938	—	—	—	—
Belgium	11,610	10,430	—	—	—	—	—
France	7,098*	11,217	—	—	—	—	—
Germany	4,920	—	—	—	—	—	—
United States	70,200*	113,924*	262,582	495,034	524,291	387,066	202,419
Other Countries ...	7,715	—	11,512	10	—	—	—
Quantity, Total (long tons)	120,335	182,065	284,032	495,044	524,291	387,066	202,419
	£	£	£	£	£	£	£
Value, Total†	181,400	275,300	554,200	1,475,200	3,014,900	2,546,800	987,067
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Value, per ton... ...	30 8	30 3	39 0	59 7	115 0	131 7	97 6

The quantities shown in the above table as having been exported during 1913 represent percentages as follows :—

To	Per cent. of total Exports.
United Kingdom	15·62
Belgium	9·65
France	5·89
Germany	4·09
United States	58·34
Other Countries	6·41
Total	100·00

* Actual receipts from Brazil during 1913.

† Report on the General Economic and Financial Conditions of Brazil for the year 1919, p. 61 ; British Dept. of Overseas Trade, London.

There were apparently no exports of manganese ore from the deposits in the State of Bahia during the period under review except in the year 1917, when 28,916 long tons, valued at £98,652, were exported from the port of Bahia.*

Costs of Manganese Ore Production in Brazil.

C. M. Weld (*op. cit.*, 104) gives the following statement of costs per ton at four manganese ore mines in Brazil :—

—	Mine A.	Mine B.	Mine C.	Mine D.
	$	$	$	$
Mining f.o.b. railway cars	5.00	4.00	5.00	5.00
Haulage to railway station	—	—	—	2.50
Transfer from narrow to broad gauge railway cars.	—	—	0.25	0.25
Railway freight to Rio de Janeiro ...	1.50	1.50	5.35	5.40
Dockage at Rio de Janeiro	0.65	0.65	—	—
Lighterage at Rio de Janeiro	—	—	2.50	2.50
Export tax	1.85	1.85	1.90	1.85
	9.00	8.00	15.00	17.50

Mines *C* and *D* were handicapped at the date of this Report (March, 1919) by increased freight rates, whereas the other two companies were still operating under old contracts.

In addition to the above costs a State tax of $3·20 per ton was imposed during the war, while royalty charges up to $1.75 per ton were not uncommon. The total range of costs for Brazilian ore into ship was, therefore, $12.00—$22.50 per ton; and, since the low cost was for one of the largest and most important mines, it was regarded as probable that a fair average would be $15 per ton (approx.).

Ocean Freight Rates on Manganese Ores from Brazil.

The same authority (p. 105) gives the ocean freight rates on manganese ores from Brazil to England and the United States as follows :—

	Per long ton.
	$
Pre-war : Brazil to England or the United States	2·88
1916 : Brazil to the United States	5·50-6·50
1918 : Brazil to the United States	15·00

The figure for 1918, which is more than five times the pre-war rate, is understood to include insurance.

* U.S. Daily Cons. and Trade Reports, May 23, 1918 (value converted to £ sterling at the rate of $1 = 4*s.* 2*d.*).

The average rail freight during the war from the United States Atlantic seaboard to the consumer in that country is estimated to have been about $3 per long ton.

Assembling the foregoing figures, the total estimated average cost of Brazilian manganese ore delivered at United States furnaces in 1918 was $30 per long ton. On a unit basis this would be 67 cents for ore containing 45 per cent. manganese.

It is uncertain what will be done by the Brazilian Federal and State Governments with regard to the present high taxes, but other Brazilian costs will probably not be much reduced. The real difference in the future is expected to come from a fall in ocean freights. If these drop to nearly their pre-war level, it should be possible to deliver Brazilian ores to the United States consumer for about $20 per ton, this figure including $13·50 for cost into ship at Rio de Janeiro; $3 ocean freight; $1, say, for insurance; and $3 for United States rail freight to the furnace.

Brazilian ores reaching the United States were formerly of higher grade than those imported in greatly increased quantities to fill urgent orders during the war. If, as expected, the grade should now improve slightly to, say, 46 per cent. of manganese, the estimated average future unit cost delivered to the furnace becomes 40 cents. At an equal price, Brazilian ore will always have the preference over Cuban owing to the higher content of metallic manganese.

It was reported in 1917* that the State of Minas Geraes had increased the existing export duty on manganese ore, which includes an *ad valorem* tax and a special or super-tax also based on the value. On the basis of the proposed official valuation of exported manganese ore at 120 milreis per metric ton, these duties together equal about 12*s*. 8*d*. per long ton.

In 1920,† a law was sanctioned whereby exporters of manganese ore who within five years instal in the State of Minas Geraes electric furnaces for the production of ferro-manganese, and convert into that alloy at least 10 per cent. of their annual output of manganese ore, shall pay a considerably reduced export duty on ore shipments. The ferro-manganese so produced will be exempted from export duty for the first five years' working. The existing special tax on manganese ore exports is maintained.

It has recently been announced that the United States Steel Corporation has purchased the Morro da Mina mine in Minas Geraes.

Chile.

Manganese ores occur in Chile in the Huasco and Carrizal districts of Atacama; the Los Chorros, Las Cañas, La Liga,

* U.S. Commerce Repts., Nov. 3, 1917.
† Reuter cablegram, Oct. 10, 1920.

Arrayan and Corral Quemada districts of Coquimbo; and the Aculeo district of Santiago. During the years 1885 to 1905 several of the deposits were worked, chiefly in the Carrizal and Corral Quemada districts, but also in the Las Cañas and La Liga districts, the total exports of manganese ore for that period being nearly 550,000 long tons. The ore was shipped from the ports of Carrizal and Coquimbo. No manganese ore was exported from Chile after 1905 until 1917, when some of the mines were re-opened.

Chilean manganese ores have been classed, according to their geological occurrence, under three heads*: (1) those occurring interbedded with jasper and chert in a limestone-chert formation, as in the Huasco and Carrizal districts; (2) those occurring interbedded with red sandstone, shale, and limestone, which in turn are interbedded with massive volcanic flows, as in the Las Cañas, La Liga, Arrayan and Corral Quemada districts; and (3) those occurring as veins in volcanic flows, as in the Aculeo and Los Chorros districts.

The Carrizal district is situated between Huasco and Carrizal. In the northern part of the manganiferous belt, which is several miles in extent, there are from one to three beds of manganese ore (psilomelane), varying in thickness from less than a foot to four or five feet, generally separated by only a few feet of chert or jasper. The beds are continuous, but pinch out locally, new ones coming in. The southern portion of the ore belt is comparatively short, and shows several breaks of continuity. The principal part contains four parallel beds of ore (braunite, with some psilomelane and soft black oxides) of which the two lowest have been extensively worked, the upper one having an average thickness of $3\frac{1}{2}$ feet, but being considerably mixed with jasper.

In the Las Cañas, La Liga, Arrayan and Corral Quemada districts only one bed of manganese ore occurs, while elsewhere two or three parallel beds are found, usually within a few feet of each other. These range in thickness from mere seams up to $4\frac{1}{2}$ feet, but where mined usually average $1\frac{1}{2}$ to 3 feet. The ore is pyrolusite. It is generally closely associated with limestone, and in many localities is intermixed with limestone in about equal amount. The manganese-bearing sediments sometimes extend over considerable areas, but are more commonly of limited extent.

The deposits are by no means exhausted, and it is suggested that the present activity in the development of the Chilean iron ores and the opening of the Panama Canal may have some effect on the manganese situation.

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* E. C. Harder; Manganese Ores of Russia, India, Brazil and Chile: Trans. Amer. Inst. M.E., New York, 1916, *56*, 62–68.

Analyses of Manganese Ore from Chilean deposits.

(Lerch Bros., Virginia, Minn., quoted by E. C. Harder, *loc cit.*)

	Analysis: Per cent.				
	Manganese.	Iron.	Silica.	Phosphorus.	Water (combined).
Carrizal District:					
Coquimbana	45·82	2·74	5·42	0·093	3·78
Huasquina	37·08	3·21	11·97	0·116	3·48
Province of Coquimbo:					
Mina Aita, Las Cañas	40·31	3·38	11·20	0·022	1·15
Mina Potosi, Las Cañas	52·85	1·09	7·74	0·007	0·90
Mina Estrella, La Liga	49·54	1·29	5·00	0·010	1·00
Elsie Cut, Corral Quemada.	50·00	0·78	9·43	0·013	1·18

The output of manganese ore in Chile since production was resumed appears to have been entirely exported to the United States.

Exports of Manganese Ore from Chile to the United States.

(U.S. Bureau of Foreign and Domestic Commerce, Dept. of Commerce.)

	1916.	1917.	1918.	1919.
Quantity, long tons ...	—	202	2,998	441
	£	£	£	£
Value,* total	4	1,319	10,158	2,906
	s. d.	*s. d.*	*s. d.*	*s. d.*
Value per ton	—	130 7	67 9	131 9

Ecuador.

Manganese ore deposits covering an area of about 1⅛ square mile near San Antonio, province of Pichincha, were exploited in 1918, 107 long tons of ore, value £713, being shipped in that year to the United States. In 1919, 20 tons of ore, value £134, was received in the same country from Ecuador. The principal deposit, apparently a bedded vein of manganese oxides, varies in thickness from 3 to 9 feet over an area of about half an acre. An assay made in New York of ore from this locality gave the following percentages: manganese, 46·36; iron, 1·55; silica, 6·44; phosphorus, 0·14; copper, 0·02. Other samples showed 53·2 per

* Values converted to £ sterling at the rate of $1 = 4s. 2d.$

cent. of manganese. Some have a higher percentage of silica, and some are mixed with limestone. The deposit lies at an elevation of 7,874 feet, and the conditions are favourable for cheap production.

Samples from many other deposits in the vicinity, of undetermined extent, appear to be of equal quality, from which it is assumed that many thousands of tons of manganese ore can be developed in this region.*

Uruguay.

Manganese ores are found in many parts of this Republic, but most of the known deposits are too small or of too low grade for exploitation, while the working of the larger and higher-grade deposits is prevented by the absence of adequate transportation facilities.

Deposits of manganiferous iron-ores occur in the Departments of Rivera, Florida, and Rocha. Of these, the most notable occurrence is that near the Arroyo Zapucay, in Rivera, about 75 miles from the Central Uruguay Railroad, and more than 300 miles from Montevideo, the only port at present available. In this locality, two hills are stated to be made up almost entirely of ore, branches of the deposits extending for nearly 2 miles into the neighbouring hills. At the surface, the ore is a mixture of wad, psilomelane, and magnetite, and is stated by R. Marstrander† to have the following average percentage composition: iron, 34·8; manganese, 22·7; silica, 9·0; phosphorus, 0·03; and sulphur, 0·05. The mining rights are covered by concessions extending over 22,000 acres, granted to the Uruguay Manganese Company. It has been estimated that 80 million tons of ore could be taken out by open-cuts; but, owing to the lack of transportation facilities, the deposits are not being exploited, although a certain amount of development has been done. A large deposit of similar ore occurs at Caraguatá in the eastern part of Rivera, where, however, the transport conditions are worse than those in the Zapucay district.

A deposit at Carrasco, about 10 miles east of Montevideo, is being worked on a small scale. This ore-body has a length of 500 to 600 feet and a width in some places of 165 feet, the ore being stated to contain 30 to 40 per cent. of manganese. The ore is used in glass manufacture.

At Pantanoso, in the immediate vicinity of Montevideo, a 16-feet vein composed of small stringers is being worked, and ore has been extracted to a depth of 90 feet. During the period

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* U.S. Consul General at Guayaquil, Dec. 19, 1918.

† Preliminary Report on the Mineral Resources of Uruguay: *Ministerio de Industrias, Instituto de Geologia y Perforaciones*, Bull. No. 2, 1915.

January-August, 1918, some 16 tons of manganese ore from this mine were exported to Argentina for use in glass factories.

Official statistics for Uruguay show 2 tons of manganese ore exported in 1915 and 1 ton in 1917.

China.

Deposits of manganese ore are found over an extensive region in Southern China, in the provinces of Kiangsi, Hunan, Kwantung and Kwangsi; but any production and export of such ore was due entirely to the war, and many of the mines ceased working after the Armistice.

The deposits in the Canton district, province of Kwantung, are large and easily accessible, but owing to high freight-rates there is practically no market for the ore. With favourable shipping conditions there should be a good export trade in this mineral.

Some export of manganese ore was reported in 1916 and 1917 from Pakhoi, in the same province, 12 miles south-east of Lienchou-fu, of which it is the port, and a property on the Lienchou river was opened in the latter year. Near Pakhoi, the Yu Ch'in Company's mines at Nata, closed down in 1916, were re-opened towards the end of 1918, and supplies were then being stacked for shipment to Japan.

In the district of Wuchou, the commercial capital of Kwangsi province, there was considerable mining activity in 1918, the exports of manganese ore from that locality amounting to 10,678 long tons; but production ceased abruptly at the end of the war.

Manganese ore has been mined by the Hanyang Iron Works Company, in Hunan province, for smelting with their iron ore.

Exports of manganese ore are included under the heading "Ores, Unclassed" in the annual Returns of Trade and Trade Reports, Chinese Maritime Customs, but it is known that the United States received shipments as follows in 1917-19 :—

Imports of Chinese Manganese Ore into the United States.

——	1917.	1918.	1919.
Quantity	Long tons. 20	Long tons. 2,997	Long tons. 1
Value,* total	£ 91	£ 30,606	£ 6
Value per ton	*s. d.* 91 0	*s. d.* 204 3	*s. d.* 120 0

* Values converted to £ sterling at the rate of $1=4s. 2d.

Manganese ore was imported into China during the years 1913-1919, the Chinese Maritime Customs Reports giving the following details :—

Imports of Manganese Ore into China.

Year.	Quantity.	Value.	Average Haikwan Tael exchange.
	Long tons.	Haikwan Taels.	*s.* *d.*
1913	13	1,341	3 $0\frac{1}{4}$
1914	498	30,276	2 $8\frac{3}{4}$
1915	4	195	2 $7\frac{1}{8}$
1916	9	425	3 $3\frac{3}{16}$
1917	9·5	1,089	4 $3\frac{3}{16}$
1918	275	28,137	5 $3\frac{7}{16}$
1919	17	674	6 4

Japan.

Manganese ore is widely distributed throughout Japan, but is now mined chiefly in Hokkaido and Kyoto, the remainder of the production coming from Gifu, Aomori, Oita, Tochigi, Nagano, and Shidzuoka prefectures. The most widely distributed and economically important deposits of the ore are found in quartzite, hornstone, radiolarian slate, or schalstein, most of these rocks belonging to the Palæozoic age. In the majority of cases, the deposits are lenticular or irregular in form, lying nearly parallel with the bedding of the rock in which they occur, and varying in size from small lumps to masses of ore weighing more than a hundred tons. As a rule the ore is mined, by open cuts or shallow pits, exclusively in the zone of oxidation, where it is probably a mixture of psilomelane, pyrolusite, wad and other oxides. Rhodonite is often found in the underground workings, suggesting that the ore mined was derived from rhodonite or some other manganese silicate.* Carbonate ores, previously neglected, have recently been mined.

The prices of ordinary Japanese manganese ores for metallurgical uses are commonly calculated on the percentage of manganese, a basis of 45 per cent. being usual; but for Japanese "brown-stone" ore (a pyrolusite of exceptionally high grade) special rates rule, based on the percentage of manganese dioxide. This ore is specially suited for chemical purposes. According to G. T. Holloway† it contains from about 43 to 56 per cent. of manganese, 7 to 10 of silica, and about 0·5 per cent. of phosphorus; and the schedule of prices is agreed at so much per

* Mining in Japan : Bureau of Mines, Tokyo, Japan, 1909, 99-10[illegible].

† Notes on the valuation of ores and minerals : Trans. Inst. M.M., London, 1912, *21*, 567.

ton if from 85 to 90 per cent. of manganese dioxide, or so much from 75 to 85 per cent., 70 to 75 per cent., or 65 to 70 per cent. Japanese brown-stone containing 87 per cent. of manganese dioxide (about the best obtainable) fetches about twice as much as 70 per cent. ore; while certain Continental pyrolusites, containing about 50 per cent. available manganese dioxide and stated to be marketable in the United States, fetch only about one-fifth as much as the 87 per cent. Japanese ore.

Production of Manganese Ore in Japan.

The expansion of the domestic iron and steel industries in Japan during the war, largely in connection with shipbuilding, created an abnormal demand for manganese in that Empire This resulted in a great increase in the domestic output of manganese ore, the production of which for the period under review was as follows :—

(35th Statistical Report.)

Year.	Quantity (long tons).
1913	17,755
1914	16,803
1915	25,470
1916	48,547
1917	50,579
1918	56,109
1919	—

Of the output in 1918, Kyoto produced 10,903 long tons, valued at £38,707 (71*s.* per ton) and Hokkaido 8,218 tons, valued at £29,804 (72*s.* 6*d.* per ton). The remainder, 36,988 tons, valued at £134,229 (72*s.* 7*d.* per ton), was produced in Gifu and the other prefectures mentioned above. No statistics are available for 1919, but it is estimated that the production of manganese ore was small, owing to the decreased domestic demand after the cessation of hostilities

In 1918, Japan proper consumed 47,426 long tons of manganese ore, two-thirds of which was used in the manufacture of iron and steel and the remainder for smelting and other purposes. It is believed that the consumption in 1919 was not more than from one-third to one-half of that in 1918.*

Exports of Manganese Ore from Japan.

The principal countries to which manganese ore is exported from Japan are the United States, the United Kingdom, France and China. Complete statistics of such exports during the period under review are not available. In 1913, the exports amounted to only 22 long tons, no ore being exported in 1914.

* U.S. Commerce Reports, 1920, No. 191, 791.

The figures for the next three years are as follows:—1915, 2,950 tons; 1916, 6,317 tons; 1917, 5,434 tons. In 1918, the quantities of manganese ore exported to the countries mentioned above aggregated 2,335 long tons, valued at £36,692 (314*s.* 3*d.* per ton), and in 1919 they amounted to 2,750 long tons, valued at £49,451 (359*s.* 8*d.* per ton).* The quantities and values of Japanese manganese ore as actually received in the United Kingdom and the United States during the period under review are given in the tables for those countries.

Imports of Ferro-manganese into Japan.

Complete statistics for these imports for the period under review are not available.

In 1918, Japan imported ferro-manganese as follows:—

(U.S. Commerce Reports, 1920, No. 191, 791.)

——	Quantity.	Value.	Value per ton.
	Long tons.	£	£
From the United Kingdom ...	252	12,982	51·52
From Australia	506	29,404	58·11
Total	758	42,386	55·92

Philippine Islands.

Manganiferous ores occur in Luzon, the largest of the Philippine Islands, in the provinces of Ilocos Norte, Pangasinan, Bulacan and Tarlac; also in the island of Masbate, south of Luzon.

The most important of the known deposits are those in the eruptive conglomerate region of Nagpartian, in Ilocos Norte, where the most promising occurrences lie between Punta Negra and Punta Blanca. In this region, innumerable small nodules of pyrolusite and limonite are scattered over the surface, in stream beds and in the hill tops, while a great number of veinlets of manganese oxide, varying in width from less than a quarter of an inch up to 2 inches, have been found between boulders of eruptive rock. The width of the veinlets is approximately the same as the thickness of the surface nodules, all of which are more or less flat and of greater length than width. The lateral distribution of the surface mineral, which has resulted from the weathering of the manganese veins, appears to be extensive; but in 1907 not more than 2 feet thickness had been exposed, and it remained to be proved whether more than

* *Ibid.* (Values converted to £ sterling at the rate of $1 = 4*s.* 2*d.*)

one bed of concentrates existed. An analysis of the ore yielded* :—

	Per cent.
Manganese dioxide	77·51
(Manganese	48·93)
Ferric oxide	4·04
Silica	1·10
Phosphorus pentoxide	0·02
Water	10·58

Manganiferous ores are found in other localities in intimate association with auriferous calcite and quartz veins, but no production therefrom has been reported, although some of the deposits are stated to warrant exploration. An analysis of a manganese nodule from Masbate showed a content of 44 oz. of silver per ton.†

In 1909, manganese ore to the value of £1,300 was shipped from the Philippine Islands, but no subsequent output was recorded until 1916, when 2,952 long tons, value £3,125, were produced, and shipped to Japan.‡ This ore was obtained by the Philippine Manganese Company from their deposits in Ilocos Norte. The bulk of the shipment was nodular surface ore, the removal of which is stated to have exposed massive beds of manganese ore of good quality.§ No production is recorded for 1917, but in 1918 there was an output of 640 long tons of manganese ore, value £938. In addition to the American demand, a good market awaits the output of these deposits, which is expected to show a large increase when shipping facilities are improved.

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* W. D. Smith; The Asbestos and Manganese Deposits of Ilocos Norte: Philippine Journal of Science, Manila, 1907, *2*, 170–171.

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